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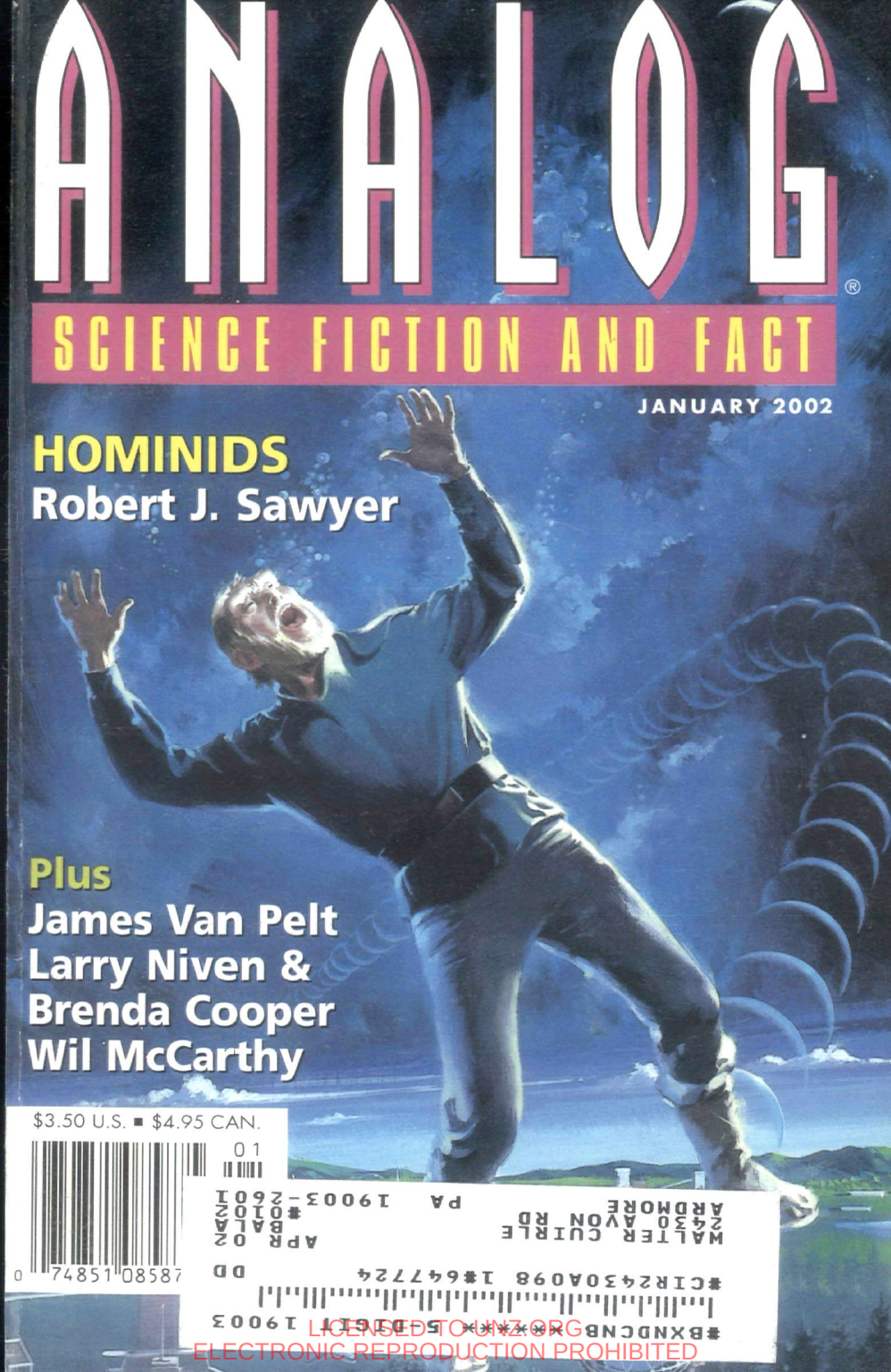

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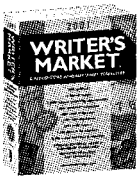

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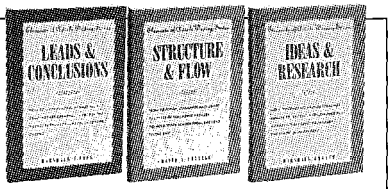

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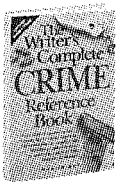

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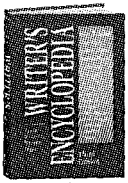

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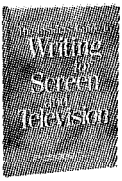

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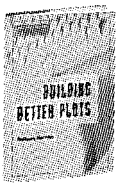

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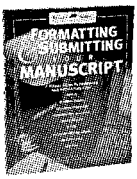

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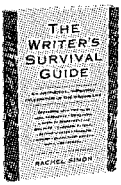

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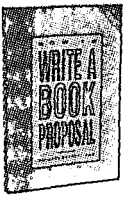

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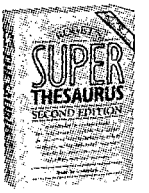

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Vol. CXXII No. 1
January 2002

Next Issue on Sale
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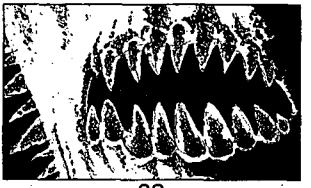

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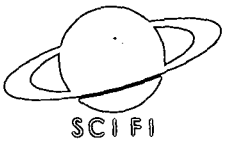

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MAGIC BULLETS

The U.S. Central Intelligence Agency, I'm told, is now forbidden (in part as a result of scandals associated with some past attempts) to use assassination of foreign officials as one of its tools. This would seem, at least on the face of it, to be a commendable thing. After all, when you describe it as murder, assassination sounds—well, beneath the dignity of a civilized nation. And if the individual targeted is a chosen leader of a people, that makes it all the more egregious.

Or does it? What if refusal even to consider causing the death of one prominent and exceedingly troublesome individual results indirectly but traceably in the death of many others who are less prominent—and less troublesome? I suspect most of my readers can easily imagine a situation in which one person continually oppresses his own citizens and is a perennial thorn in the side of practically everyone else. Conceivably you might even be able to dredge up a real-life historical example or two.

Let us further imagine that one or more other nations, having had enough trouble from this guy, decide that the only real solution to the miseries he causes, at home and abroad, is to get him out of power. To this end, they invade his country, hitting it hard with artillery and bombs. After unexpectedly heavy destruction and casualties, Mr. Thorn surrenders, to end the war, and his attackers place his country under severe economic sanctions, which stay in place for several ensuing years. Mr. Thorn now has somewhat less power to cause trouble for the attacking nations, and they take pride in their victory.

But what has actually changed? Mr. Thorn, who was supposedly the problem to be eliminated, is still alive, reasonably well, and enjoying (and possibly abusing) considerable power over people within his own country. But many thousands of those people were killed in the war, and many more are suffering and sometimes dying, more slowly but just as surely, as a result of the economic sanctions.

Is this really what the invading nations wanted? Or, if Mr. Thorn was really such a concentration of evil power that he was personally responsible for all those problems at home and abroad, might it not have been better for everybody to take a more "surgical" approach, targeting Mr. Thorn directly and personally, eliminating him cleanly and irrevocably, without damage to other persons or property?

Anybody who has read much of what I've written surely knows that I personally consider violence an extreme last resort when it comes to problem-solving, and terminal violence the extremest of the extreme. Yet logically, how can we justify a policy that considers killing one person an unthinkable alternative to killing many, if those are the only choices?

I'm at least dimly aware of some of the political problems. Yes, heads of state—even nasty dictators who clawed

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their way to power—are considered special. Perhaps more special than they should be, but that's another question to which I will later return briefly. For now, I will simply stipulate that for representatives of one government to visibly and premeditatedly kill the head of another would provoke a great deal of outrage, both in the "target" country and elsewhere. And not without justification. Even if everybody agrees that Mr. Thorn deserves to die and everybody else will be better off without him, meddling in the top levels of somebody else's government is not something that should be encouraged. It can't even be tolerated without an *extremely* special justification, and any attempt at such a justification must be examined *very* critically.

So, even though it seems colossally ironic that lots of bombs and bullets directed at "unimportant" people are generally considered more acceptable than a single bullet with Mr. Thorn's name on it, I can understand that such a bullet carries with it subtle but large risks that can't be taken lightly. They, I suspect, are the real main reason for the current ban on assassination as an instrument of policy. It's been tried in the past, and the consequences were too embarrassing in diplomatic circles.

But how about a "magic" bullet—a weapon that *can't* kill anybody except Mr. Thorn, and can do that very sneakily, perhaps even undetectably? Suppose the nation or alliance that wants to get rid of Mr. Thorn can deliver this weapon invisibly and untraceably, so that nobody knows they did it, and that Mr. Thorn appears to die of natural causes. Then, perhaps, with Mr. Thorn off their backs, the people he's been oppressing can try to set up a better government, both for their own welfare and for dealing with the outside world, without the turmoil and emotional reactions that would follow his obvious assassination by a foreign power.

Biologists are at least close to being able to do this. The weapon would be a biological agent which is only activated by contact with the DNA of a particular individual. Charles Sheffield, in his book *Borderlands of Science* (Baen Books, 1999), has described in some detail how one such method might work; Nancy Kress has described a fictional application of the idea (in a rather different context) in her novel *Oaths and Miracles* (Tor Books, 1996).

The basic idea depends on the fact that every individual (except an identical twin or clone) has unique DNA that defines who he or she is. One of the jobs of that DNA is to produce a molecule called "MHC" (major histocompatibility complex), also unique to that individual and functioning as an "IFF" (identification friend or foe) device for the immune system. Everybody has "T cells" working full-time to eliminate viruses that have entered the body and don't belong there (which also happens all the time, with every breath, drink,

Analog Science Fiction and Fact (Astounding) USPS 488-910 is published monthly except for a combined July/August double issue by Dell Magazines, a division of Crosstown Publications. One-year subscription for $39.97 in the U.S.A. and possessions, in all other countries, $47.97 (GST included in Canada, GST # 123054108) payable in advance in U.S. funds. First copy of new subscription will be mailed within eight weeks of receipt of order. When reporting change of address allow 6 to 8 weeks and give new address as well as the old address as it appears on the last label. Periodical postage paid at Norwalk, CT and additional mailing offices. Canadian postage paid at Montreal, Quebec. Canada Post International Publications Mail, Product Sales Agreement No. 260622. © 2001 by Dell Magazines, a division of Crosstown Publications, all rights reserved. Protection secured under the Universal Copyright Convention. Reproduction or use of editorial or pictorial content in any manner without express permission is prohibited. All stories in this magazine are fiction. No actual persons are designated by name or character. Any similarity is coincidental. All submissions must be accompanied by stamped self-addressed envelope, the publisher assumes no responsibility for unsolicited manuscripts or artwork. ISSN 1059-2113

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IN CANADA RETURN TO: Transcontinental Sub Dept, 525 Louis Pasteur, Boucherville, Quebec, J48 8E7
Executive Office: Penny Press, 6 Prowitt St., Norwalk, CT 06855
Editorial and Advertising: Analog Science Fiction and Fact, 475 Park Avenue South, New York, N.Y. 10016
Subscriptions: Analog Science Fiction and Fact, P.O. Box 54027, Boulder, CO 80322-4027

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cut, etc.). Things that belong in a particular body have a coat of that body's MHC which is recognized as "friend" and left alone by that body's T cells; things that lack such a coat are regarded as "foe" and destroyed.

Now suppose you can get hold of a sample of Mr. Thorn's DNA, which is not all that hard. Any cell will do: a hair, a flake of skin sloughed off into a discarded item of clothing, a fingernail clipping. . . . Given suitable maps of the human genome and suitable DNA-sequencing equipment, it's a relatively small step to preparing a batch of some lethal disease-producing virus with a coat of Mr. Thorn's MHC. Release it into his general neighborhood—say, the city where he spends most of his time—and everybody there starts breathing it. To *almost* everybody, Mr. Thorn's MHC looks as alien and hostile as the virus itself; their T cells destroy the entire package, including the virus, and they're not even aware of having been exposed. But if the virus reproduces to some extent, and citizens keep breathing and socializing, the virus spreads. Sooner or later, it will reach Mr. Thorn himself; and his T cells, unlike anybody else's, see the virus (in its coat of his very own MHC) as "one of his own." So they ignore it, the virus begins happily multiplying, and pretty soon Mr. Thorn is mortally ill. And then he is gone, with no evidence that his demise resulted from anything other than an unfortunate but perfectly natural infection.

And with no diplomatic repercussions, since there's nothing to suggest any involvement by those who carried out the plot.

Now . . . if we can agree that under some circumstances a specific individual really is such a danger to world peace and welfare that getting truly rid of him is the only real solution, which is better? A method that assassinates him, and him alone, without hurting anyone else in his country or calling attention to anyone else as his killer, or a method that inconveniences him slightly but everybody else in his country a lot, and actually kills a great many of them—but not him?

From the viewpoint of civilized folk, confident that they are truly defenders of human rights and rightness, genuinely wanting to do as little harm as possible, the choice seems almost irresistibly clear. And yet . . .

There are traps embedded in the idea

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First issue of Astounding January 1930 ©

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that should give us pause. For one, how can we be so sure that our cause is so just and right as to warrant following *either* of those courses? We may feel *very* sure of that—but so do the proponents of certain agendas that we may see as dangerously fanatical. I'm not saying that this question can't be answered in a reasonable way, but it is one that should disturb us and make us think long and hard before getting too smug in our righteousness.

A second trap lies in the question of accountability. Suppose that we do have the ability to design an untraceable magic bullet to kill a particularly troublesome leader of some enemy, an ability that may well be within our grasp quite soon. Might its untraceability tempt us to use it too casually and too often? I think that danger is very real and very frightening. There's a well-known saying that power corrupts, and absolute power corrupts absolutely. John W. Campbell observed that it isn't really *power* that corrupts, but *immunity*. That is, corruption results not from being able to wield power *per se*, but from being able to wield it without being held accountable for the consequences. If that is so, what could be more corrupting than the ability to take powerful actions, not only without being held responsible for them, but without anybody else's even knowing that an action has been taken?

A third trap lies in another observation of Campbell's: "Mother Nature is a blabbermouth." We may gain a big edge if we can do this to somebody else, but that edge is temporary. If we can figure out how to do it unto Them, They can figure out how to do it unto us. So maybe we'd better all give this a lot of thought, from both offensive and defensive points of view, before we start down that road. Since anybody who knows enough biotechnology *can* do it, we may be forced to learn as much as we can about how it might be done—and no less about how it might be defended against. And in the meantime, maybe somebody should be trying to hatch a way to make sure *nobody* does it.

Or maybe something even grander. While we're speculating, let's go all out and look at an even wilder challenge—not a biotechnological invention, but a social one. If "magic bullets" look tempting as a way to deal with an alpha male who's gotten out of control, might there be a way to prevent that from happening in the first place? It can easily be argued that most, if not all, human societies have recognizably evolved from the kinds of hierarchies found in ape clans or wolf packs, and that human technologies have allowed far too much power over too many individuals to be concentrated in a single individual. Can we imagine a different way to structure a human culture so that it could function as a true civilization, and defend itself against outside threats, without allowing any one individual to become so important that things like magic bullets need to be considered? ■

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POUL ANDERSON, 1926-2001

Poul Anderson died August 1, 2001, at his home in Orinda, California, of prostate cancer. Born in Bristol, Pennsylvania, on November 25, 1926, he grew up largely in Texas and Minnesota. He graduated from the University of Minnesota, with a degree in physics, but that was only a small part of his education; he was interested in, and made himself knowledgeable about, just about everything.

His first fiction sale was a novelette written in collaboration with F. N. Waldrop, published in this magazine (then called *Astounding*) in 1947. He quickly became a full-time writer and remained one of the most prolific and versatile in the field for the rest of his life. His output included numerous novels and shorter pieces in an extraordinarily wide variety of genres, but he was particularly known for his own distinctive kinds of science fiction and fantasy. He won numerous Hugo, Nebula, Gandalf, and other awards, served as president of the Science Fiction Writers of America, and was Guest of Honor at the 1959 World Science Fiction Convention as well as many regional conventions.

It would be impossible to give an adequate representation of the range of his work here, but a few samples may faintly suggest it: *Tau Zero*; *World Without Stars*; *A Midsummer Tempest*; *The People of the Wind*; *A Bicycle Built for Brew*; the Polesotechnic League, Terran Empire, and Time Patrol series; and the "Hoka" stories he co-wrote with Gordon R. Dickson. The flavor of his huge and remarkably varied output is well suggested by a few phrases from perhaps his best biographer and critic, Sandra Miesel: "Anderson is perhaps SF's finest world-builder" and "Anderson's fiction is rational in concept, romantic in execution." Perhaps no one else has so seamlessly woven physics, poetry, and everything between into memorable literature. He himself once remarked that the best science fiction requires a "unitary" approach, in which "philosophy, love, technology, poetry, and the minutiae of daily living would all play parts concomitant with their roles in real life, but heightened by the imagination of the writer." It would be hard to find a better example of that philosophy than Poul himself.

Personally, he was, as Jay Kay Klein said in his Biolog, "a gourmet, wine connoisseur, world traveler, hiker, sailer, carpenter, gardener, and a member of the Baker Street Irregulars and the Society for Creative Anachronism." In other words, he lived life as fully as he wrote about it, and loved sharing it with his wife Karen, daughter Astrid, and son-in-law Greg Bear. They have asked that anyone wishing to make contributions in his memory send them to the SFWA Emergency Medical Fund, 1436 Altamont Avenue, PMB 292, Schenectady, NY 12303-2977.

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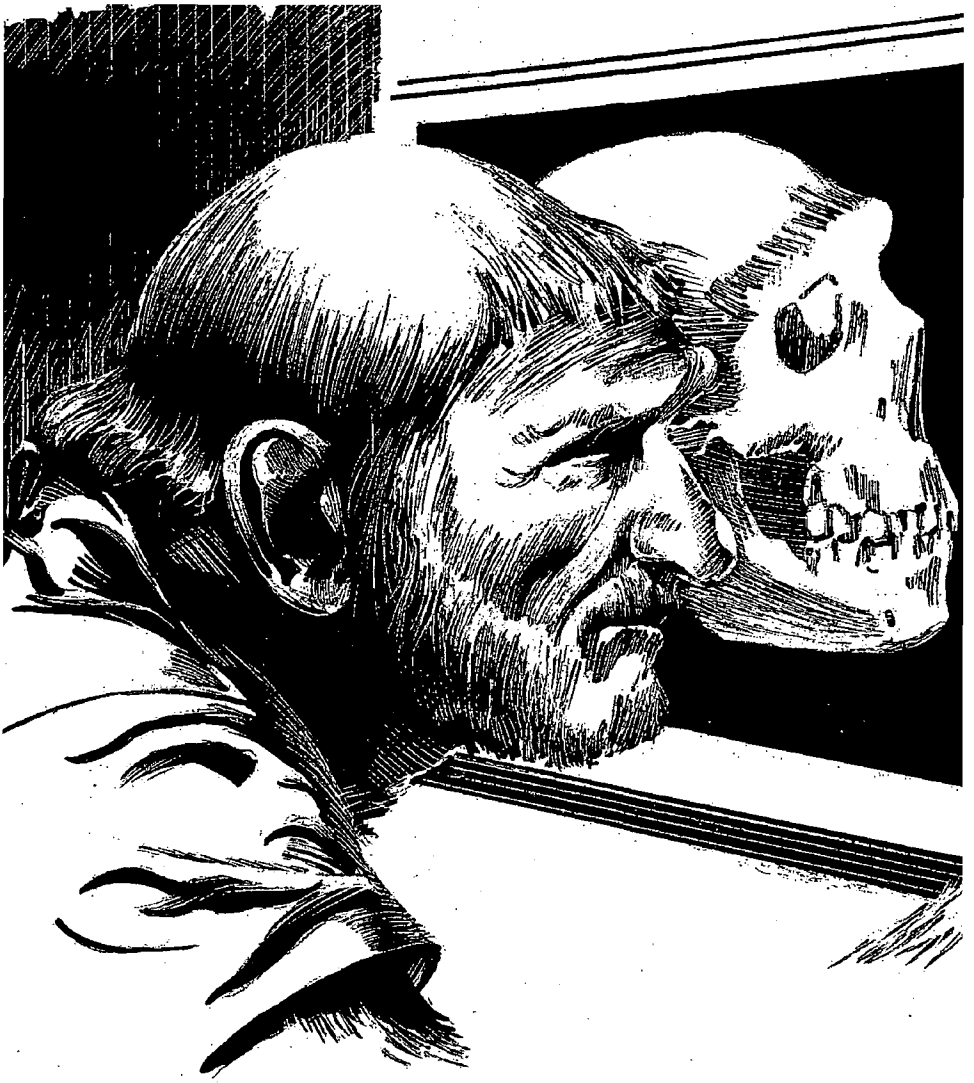

Almost any experiment teaches us something, but not always necessarily what we expected. And it may raise more questions than it answers. . . .

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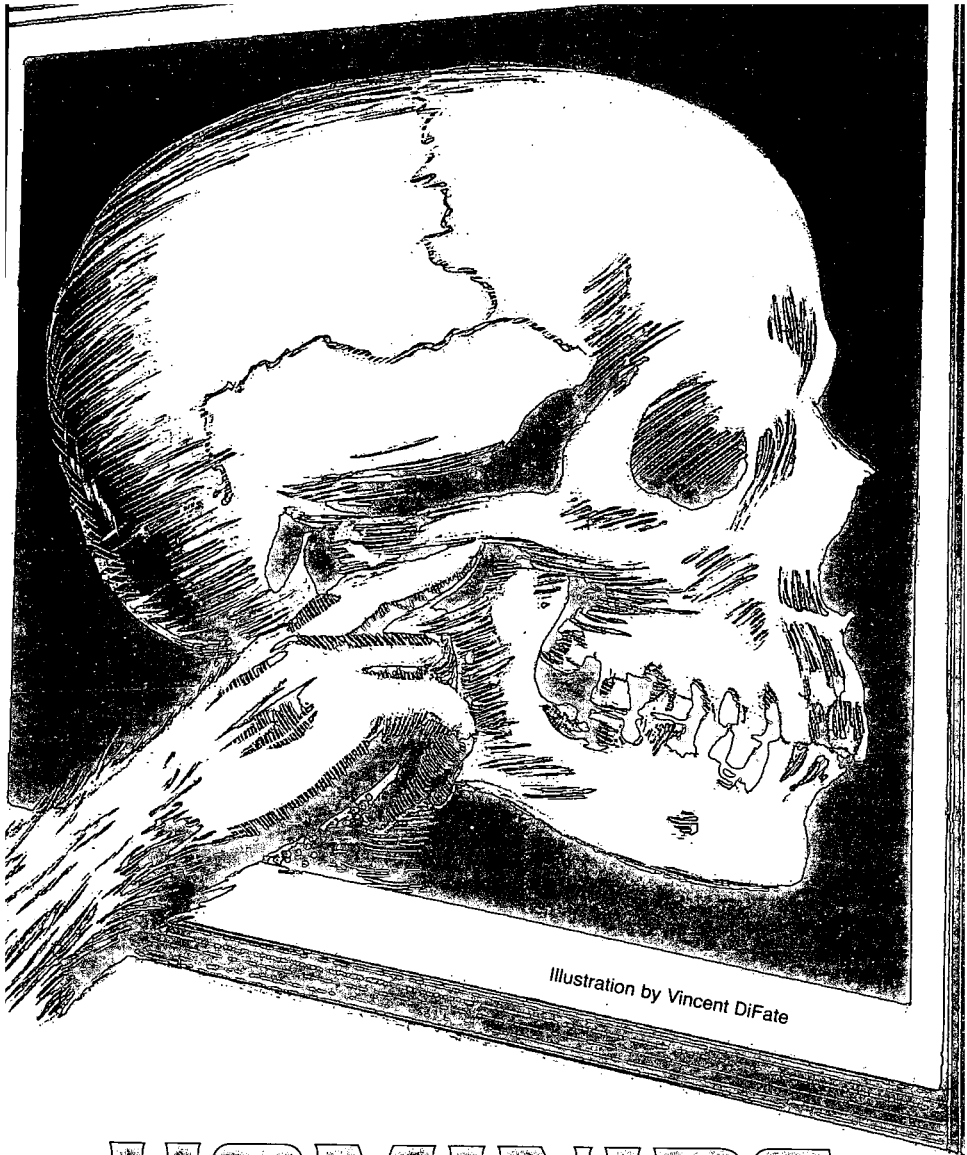

Illustration by Vincent DiFate

HOMINIDS

part I of IV

Robert J. Sawyer

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The southern forests provide the message that it didn't have to be this way, that there is room on the earth for a species biologically committed to the moral aspects of what, ironically, we like to call "humanity": respect for others, personal restraint, and turning aside from violence as a solution to conflicting interests. The appearance of these traits in bonobos hints at what might have been among Homo sapiens, if evolutionary history had been just slightly different.

—Richard Wrangham
& Dale Peterson
Demonic Males: Apes and the Origins of Human Violence

You have zero privacy anyway. Get over it.

—Scott McNealy
Chief Executive Officer
Sun Microsystems

Chapter 1

DAY ONE
Friday, August 2
148/118/24

The blackness was absolute.

Watching over it was Louise Benoît, twenty-eight, a statuesque postdoc from Montreal with a mane of a thick brown hair stuffed, as required here, into a hair net. She kept her vigil in a cramped control room, buried two kilometers—"a mile an' a quarder," as she sometimes explained for American visitors in an accent that charmed them—beneath the Earth's surface.

The control room was next to the deck above the vast, unilluminated cavern housing the Sudbury Neutrino Observatory. Suspended in the center of that cavern was the world's largest acrylic sphere, twelve meters—"almost fordy feet"—across. The sphere was filled with eleven hundred tonnes of heavy water on loan from Atomic Energy of Canada Limited.

Enveloping that transparent globe was a geodesic array of stainless-steel struts, supporting 9,600 photomultiplier tubes, each cupped in a reflective parabola, each aimed in toward the sphere. All of this—the heavy water, the acrylic globe that contained it, and the enveloping geodesic shell—was housed in a ten-story-tall barrel-shaped cavern, excavated from the surrounding norite rock. And that gargantuan cavern was filled almost to the top with ultrapure regular water.

The two kilometers of Canadian shield overhead, Louise knew, protected the heavy water from cosmic rays. And the shell of regular water absorbed the natural background radiation from the small quantities of uranium and thorium in the surrounding rock, preventing that, too, from reaching the heavy water. Indeed, nothing could penetrate into the heavy water except neutrinos, those infinitesimal subatomic particles that were the subject of Louise's research. Trillions of neutrinos passed right through the Earth every second; in fact, a neutrino could travel through a block of lead a light-year thick with only a fifty-percent chance of hitting something.

Still, neutrinos poured out of the Sun in such vast profusion that collisions did occasionally occur—and heavy water was an ideal target for such collisions. The hydrogen nuclei in heavy water each contain a proton—the normal constituent of a hydrogen nucleus—plus a neutron, as well. And when a neutrino did chance to hit a neutron, the neutron decayed, releasing a proton of its own, an electron, and a flash of light that could be detected by the photomultiplier tubes.

At first, Louise's dark, arching eyebrows did not rise when she heard the neutrino-detection alarm go *ping*; the alarm sounded briefly about a dozen times a day, and although it was normal-

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ly the most exciting thing to happen down here, it still didn't merit looking up from her copy of *Cosmopolitan*.

But then the alarm sounded again, and yet again, and then it stayed on, a solid, unending electric bleep like a dying man's EKG.

Louise got up from her desk and walked over to the detector console. On top of it was a framed picture of Stephen Hawking—not signed, of course. Hawking had visited the Sudbury Neutrino Observatory for its grand opening a few years ago, in 1998. Louise tapped on the alarm's speaker, in case it was on the fritz, but the keening continued.

Paul Kiriyama, a scrawny grad student, dashed into the control room, arriving from elsewhere in the vast, underground facility. Paul was, Louise knew, usually quite flustered around her, but this time he wasn't at a loss for words. "What the heck's going on?" he asked. There was a grid of 98 by 98 LEDs on the detector panel, representing the 9,600 photomultiplier tubes; Every one of them was illuminated.

"Maybe someone accidentally turned on the lights in the cavern," said Louise, sounding dubious even to herself.

The prolonged bleep finally stopped. Paul pressed a couple of buttons, activating five TV monitors slaved to five underwater cameras inside the observatory chamber. Their screens were perfectly black rectangles. "Well, if the lights *were* on," he said, "they're off now. I wonder what—"

"A supernova!" declared Louise, clapping her long-fingered hands together. "We should contact the Central Bureau for Astronomical Telegrams; establish our priority." Although SNO had been built to study neutrinos from the Sun, it could detect them from anywhere in the Universe.

Paul nodded and plunked himself down in front of a web browser, clicking on the bookmark for the Bureau's site. It was worth reporting the event, Louise knew, even if they weren't yet sure.

A new series of pings sounded from the detector panel. Louise looked at the LED board; several hundred lights were illuminated all over the grid. Strange, she thought. A supernova should register as a *directional* source . . .

"Maybe something's wrong with the equipment?" said Paul, clearly making the same conclusion. "Or maybe the connection to one of the photomultipliers is shorting out, and the others are picking up the arc."

The air split with a creaking, groaning sound, coming from next door—from the deck atop the giant detector chamber itself. "Perhaps we should turn on the chamber lights," said Louise. The groaning continued, a subterranean beast prowling in the dark.

"But what if it *is* a supernova?" said Paul. "The detector is useless with the lights on, and—"

Another loud cracking, like a hockey player making a slap shot. "Turn on the lights!"

Paul lifted the protective cover on the switch and pressed it. The images on the TV monitors flared then settled down, showing—

"Mon dieu," declared Louise.

"There's something inside the heavy-water tank!" said Paul. "But how could—?"

"Did you see that?" said Louise. "It's moving, and—good Lord, it's a man!"

The cracking and groaning sounds continued, and then—

They could see it on the monitors and hear it coming through the walls.

The giant acrylic sphere burst apart along several of the seams that held its component pieces together. *"Tabernacle,"* Louise swore, realizing the heavy water must now be mixing with the regular H_2O inside the barrel-shaped chamber. Her heart was jackhammering. For half a second, she didn't know whether to be more concerned about the destruction of the detector or about the

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man who was obviously drowning inside it.

"Come on!" said Paul, heading for the door leading to the deck above the observatory chamber. The cameras were slaved to VCRs; nothing would be missed.

"Un moment," said Louise. She dashed across the control room, grabbed a telephone handset, and pounded out an extension from the list taped to the wall.

The phone rang twice. "Dr. Montego?" said Louise, when the Jamaican-accented voice of the mine-site physician came on. "Louise Benoît here, at SNO. We need you right away down at the neutrino observatory. There's a man drowning in the detector chamber."

"A man drowning?" said Montego. "But how could he possibly get in there?"

"We don't know. Hurry!"

"I'm on my way," said the doctor. Louise replaced the handset. She then ran toward the same blue door Paul had gone through earlier, which had since swung shut. She knew the signs on it by heart:

Keep Door Closed
Danger: High Voltage Cables
No Unauthorized Electronic
Equipment Beyond This Point
Air Quality Checked—
Cleared for Entry

Louise grabbed the handle, pulling the door open, and hurried onto the wide expanse of the metal deck.

There was a trapdoor off to one side leading down to the actual detector chamber; the final construction worker had exited through it, and had sealed it shut behind him. To Louise's astonishment, the trapdoor was still sealed by forty separate bolts—of course, it was *supposed* to be sealed, but there was no way a man could have gotten inside except through that trapdoor . . .

The walls surrounding the deck were covered with dark-green plastic sheeting to keep rock dust out. Dozens of conduits and polypropylene pipes hung from the ceiling, and steel girders sketched out the shape of the room. Computing equipment lined some walls; others had shelves. Paul was over by one of the latter, desperately rummaging around, presumably for pliers strong enough to crank the bolts free.

Metal screamed in anguish. Louise ran toward the trapdoor—not that there was anything she could do to unseal it with her bare hands. Her heart leapt; a sound like machine-gun fire erupted into the room as the restraining bolts shot into the air. The trapdoor burst open, slapping back on its hinges and hitting the deck with a reverberating clang. Louise had jumped out of the way, but a geyser of cold water leapt up through the opening, soaking her.

The very top of the detector chamber was filled with nitrogen gas, which Louise knew must be venting now. The water spout quickly subsided. She moved toward the opening in the deck and looked down, trying not to breathe. The interior was illuminated by the floodlights Paul had turned on, and the water was absolutely pure; Louise could see all the way to the bottom, thirty meters below.

She could just make out the giant curving sections of the acrylic sphere; the acrylic's index of refraction was almost identical to that of water, making it hard to see. The sections, separated from each other now, were anchored to the roof by synthetic-fiber cables; otherwise, they would have already sunk to the bottom of the surrounding geodesic shell. The trapdoor's opening gave only a limited perspective, and Louise couldn't yet see the drowning man.

"Merde!" The lights inside the chamber had gone off. "Paul!" Louise shouted. "What are you doing?"

Paul's voice—now coming from back in the control room—was barely audible above the air-conditioning equipment

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and the sloshing of the water in the huge cavern beneath Louise's feet. "If that man's still alive," he shouted, "he'll see the lights up on the deck through the trapdoor."

Louise nodded. The only thing the man would now be seeing was a single illuminated square, a meter on a side, in what, to him, would be a vast, dark ceiling.

A moment later, Paul returned to the deck. Louise looked at him, then back down at the open trapdoor. There was still no sign of the man. "One of us should go in," said Louise.

Paul's almond-shaped eyes went wide. "But . . . the heavy water—"

"There's nothing else to do," said Louise. "How good a swimmer are you?"

Paul looked embarrassed; the last thing he ever wanted to do, Louise knew, was look bad in her eyes, but . . . "Not very," he said, dropping his gaze.

It was already awkward enough down here with Paul mooning over her all the time, but Louise couldn't very well swim in her SNO-issue blue-nylon jumpsuit. Underneath, though, like almost everyone else who worked at SNO, she only had on her underwear; the temperature was a tropical 40.6 Celsius this far beneath Earth's surface. She yanked off her shoes, then pulled on the zipper that ran down the front of the jumpsuit; thank God she'd worn a bra today—although she wished now that it hadn't been as lacy.

"Turn the lights back on down there," said Louise. To his credit, Paul didn't tarry. Before he'd returned, Louise had slipped through the trapdoor into the cold water; the water was chilled to ten degrees Celsius to discourage biological growth and to reduce the spontaneous noise rate of the photomultiplier tubes.

She felt a rush of panic, a sudden feeling of being a long way up with nothing supporting her; the bottom was far, far below. She was treading water, her head and shoulders sticking up through the open trapdoor into the air, waiting for her panic to subside. When it did, she took three deep breaths, closed her mouth tight, and dived beneath the surface.

Louise could see clearly, and her eyes didn't sting at all. She looked around, trying to spot the man, but there were so many pieces of acrylic, and—

There he was.

He had indeed floated up, and there was a small gap—maybe fifteen centimeters—between the top of the water and the deck above. Normally it was filled with ultrapure nitrogen. The poor guy *must* be dead; three breaths of that would be fatal. A sad irony: he probably fought his way to the surface, thinking he could find air, only to be killed by the gas he inhaled there. Breathable air from the open trapdoor must now be mixing with the nitrogen, but presumably it was too late to help him.

Louise pushed her own head and shoulders up through the trapdoor again. She could see Paul, desperately waiting for her to say something—anything. But there was no time for that. She gulped more air, filling her lungs as much as she could, then dived under. There wasn't enough room for her to keep her nose above water without constantly banging her head into the metal roof as she swam. The man was about ten meters away. Louise kicked her feet, covering the distance as quickly as she could, and—

A cloud in the water. Something dark.

Mon dieu!

It was blood.

The cloud surrounded the man's head, obscuring his features. He wasn't moving at all; if he were still alive, he was surely unconscious.

Louise craned to get her mouth and nose into the air gap. She took one tentative breath—but there was plenty of breathable air there now—then grabbed the man's arm. Louise rolled the fellow over—he'd been floating facedown—so that his nose was sticking up into the air gap, but it seemed to make no differ-

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ence. There was no spluttering from him, no sign that he was still breathing.

Louise dragged him through the water. It was tough work: the man was quite stocky, and he was fully dressed; his clothes were waterlogged. Louise didn't have time to notice much, but it did register on her that the man *wasn't* wearing coveralls or safety boots. He couldn't possibly be one of the nickel miners, and although Louise had only gotten a fleeting glimpse of the man's face—a white guy, blond beard—he wasn't from SNO, either.

Paul must have been crouching on the deck above. Louise could see his head sticking into the water; he was watching as Louise and the man came closer. Under other circumstances, Louise would have gotten the injured person out of the water before she herself left it, but the trapdoor was only big enough for one of them to go through at a time, and it would take both her and Paul to drag this large man out.

Louise let go of the man's arm and stuck her head up through the trapdoor, Paul having now backed off from it. She took a moment just to breathe; she was exhausted from pulling the man through the water. And then she put her palms flat on the wet deck and began to lift herself up and out. Paul crouched down again and helped Louise onto the deck, then they turned back to the man.

He had started to drift away, but Louise managed to grab his arm and drag him back under the opening. Louise and Paul then struggled to get him out, finally succeeding in lifting him onto the deck. He was still bleeding; the injury was clearly to the side of his head.

Paul immediately knelt next to the man and began administering mouth-to-mouth resuscitation, his cheek getting slick with blood each time he turned to see if the man's broad chest was rising.

Louise, meanwhile, found the man's right wrist and searched for a pulse. There didn't—no, no, wait! There was! There *was* a pulse.

Paul continued to blow air into the man's mouth, over and over again, and finally the man began to gasp on his own. Water and vomit came pouring out of him. He turned his head sideways, and the liquid he was ejecting mixed with the blood on the deck, washing some of it away.

The man still seemed to be unconscious, though. Louise, soaking wet, almost naked, and still chilled from the water, was starting to feel quite self-conscious. She struggled back into her jumpsuit and then zipped it up—Paul watching her, she knew, even while he pretended not to.

It would still be a while before Dr. Montego would arrive. SNO wasn't just two kilometers down; it was also a kilometer and a quarter horizontally from the nearest elevator, at mineshaft number nine. Even if the lift cage had been at the top—and there was no guarantee it would have been—it would still take Montego twenty-odd minutes to get here.

Louise thought she should get the man out of his wet clothes. She reached for the front of his charcoal-gray shirt, but—

But there were no buttons—and no zipper. It didn't appear to be a pullover, even though it was collarless, and—

Ah, there they were! Hidden snaps running along the tops of the broad shoulders. Louise tried to undo them, but they didn't budge. She glanced down at the man's pants. They seemed to be dark olive green, although they might have been much lighter if dry. But there was no belt; instead, a series of snaps and folds encircled the waist.

It suddenly occurred to Louise that the man might be suffering from the bends. The detector chamber was thirty meters deep; who knew how far down he'd gone or how quickly he'd come up? Air pressure this much below Earth's surface was 130 percent of normal. At that moment, Louise couldn't figure out how that would affect whether some-

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one got the bends, but it did mean the man would now be receiving a higher concentration of oxygen than he would have up top, and that surely must be to the good.

There was nothing to do now but wait; the man was breathing, and his pulse had strengthened. Louise finally had a chance to really look at the stranger's face. It was broad but not flat; rather, the cheekbones trailed back at an angle. And his nose was gargantuan, almost the size of a clenched fist. The man's lower jaw was covered by a thick dark-blond beard, and straight blond hair was plastered across his forehead. His facial features were vaguely Eastern European, but with Scandinavian rather than olive coloring. The wide-spaced eyes were closed.

"Where could he possibly have come from?" asked Paul, now sitting cross-legged on the deck next to the man. "No one should have been able to get down here, and—"

Louise nodded. "And even if he could, how would he get inside the sealed detector chamber?" She paused and brushed hair out of her eyes—realizing for the first time that she'd lost her hair net while swimming in the tank. "You know, the heavy water is ruined. If he survives this stunt, he'll face one heck of a lawsuit."

Louise found herself shaking her head. Who could this man be, anyway? Maybe a Native Canadian zealot—an Indian who felt the mining was interfering with sacred ground. But the man's hair was blond, rare among Natives. Nor was this a youthful prank gone bad; the guy looked to be about thirty-five.

It was possible he was a terrorist or an antinuclear protester. But although Atomic Energy of Canada Limited had indeed supplied the heavy water, there was no nuclear work done at this site.

Whoever he was, Louise reflected, if he did finally die from his injuries, he'd be a prime candidate for the Darwin Awards. This was classic evolution-in-action stuff: a person who did something so incredibly stupid it cost him his own life.

Chapter 2

Louise Benoît heard the sound of the opening door; someone was coming out onto the deck above the detector chamber. "Yoo-hoo!" she called, getting Dr. Montego's attention. "Over here!"

Reuben Montego, a Jamaican-Canadian in his mid-thirties, hurried over to them. He shaved his head completely bald—meaning he was the only person allowed into SNO without a hair net—but, like everyone else, he still had to wear a hardhat. The doctor crouched down, rotated the injured man's left wrist, and—

"What the heck is that?" said Reuben, in his accented voice.

Louise saw it, too: something set, apparently, into the skin of the man's wrist, a high-contrast, matte-finish rectangular screen about eight centimeters long and two across. It was displaying a string of symbols, the leftmost of which was changing about once per second. Six small beads, each a different color, formed a line beneath the display, and something—maybe a lens—was positioned at the end of the device farthest up the man's arm.

"Some kind of fancy watch?" said Louise.

Reuben clearly decided to ignore this mystery for the moment; he placed his index and middle fingers over the man's radial artery. "He's got a decent pulse," he announced. He then lightly slapped one of the man's cheeks, then the other, seeing if he could bring him to consciousness. "Come on," he said in an encouraging tone. "Come on. Wake up."

At last the man did stir. He coughed violently, and more water spilled from his mouth. Then his eyes fluttered open. His irises were an arresting golden brown, unlike any Louise had ever seen before. It seemed to take a second or two for them to focus, then they

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went wide. The man looked absolutely astonished by the sight of Reuben. He turned his head and saw Louise and Paul, and his expression continued to be one of shock. He moved a bit, as if trying perhaps to get away from them.

"Who are you?" asked Louise.

The man looked at her blankly.

"Who are you?" Louise repeated. "What were you trying to do?"

"Dar," said the man, his deep voice rising as if asking a question.

"I need to get him to the hospital," said Reuben. "He obviously took a nasty hit to the head; we'll need skull x-rays."

The man was looking around the metal deck, as if he couldn't believe what he was seeing. *"Dar barta dulb tinta?"* he said. *"Dar hoolb ka tapar?"*

"What language is that?" Paul asked Louise.

Louise shrugged. "Ojibwa?" she said. There was an Ojibwa reserve not far from the mine.

"No," Reuben said, shaking his head.

"Monta has palap ko," said the man.

"We don't understand you," said Louise to the stranger. "Do you speak English?" Nothing. *"Parlez-vous Français?"* Still nothing.

Paul said *"Nihongo ga dekimasu ka?"* which Louise assumed meant, "Do you speak Japanese?"

The man looked at each of them in turn, eyes still wide, but he made no reply.

Reuben rose, then extended a hand down toward the man. He stared at it for a second, then took it in his own, which was huge, with fingers like sausages and an extraordinarily long thumb. He let Reuben pull him to his feet. Reuben then put an arm around the man's broad back, helping to hold him up. The man must have outweighed Reuben by thirty kilos, all of it muscle. Paul moved to the man's other side and used an arm to help support the stranger as well. Louise went ahead of the three of them, holding open the door to the control room, which had closed automatically after Reuben had entered.

Inside the control room, Louise put on her safety boots and hardhat, and Paul did the same; the hats had built-in lamps and hearing-protection cups that could be swung down when needed. They also put on safety glasses. Reuben was still wearing his own hardhat. Paul found another one on top of a metal locker, and proffered it to the injured man, but before he could respond the doctor waved the hat away. "I don't want any pressure on his skull until we've done those x-rays," he said. "All right, let's get him up to the surface. I called for an ambulance on my way over."

The four of them left the control room, headed down a corridor, and walked into the arrival area for the SNO facility. SNO maintained clean-room conditions—not that it mattered much anymore, Louise thought ruefully. They walked past the vacuuming chamber, a shower-stall-like affair that sucked dust and dirt off those entering SNO. Then they passed a row of real shower stalls; everyone had to wash before entering SNO, but that, too, wasn't necessary on the way out. There was a first-aid station here, and Louise saw Reuben looking briefly at the locker labeled "Stretcher." But the man was walking well enough, so the doctor motioned for them to continue out into the drift.

They turned on their hardhat lights and began trudging the kilometer and a quarter down the dim dirt-floored tunnel. The rough-hewn walls were peppered with steel rods and covered over with wire mesh; this far beneath Earth's surface, with the weight of two kilometers of crust pressing down on them, unreinforced rock walls would burst into any open space.

As they walked along the drift, occasionally coming across muddy patches, the man began to take more of his own weight; he was clearly recovering from his ordeal.

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Paul and Dr. Montego were engaged in an animated discussion about how this man could have possibly gotten into the sealed chamber. For her part, Louise was lost in thought about the ruined neutrino detector—and what that was going to do to her research funding. Air blew into their faces all the way along the drift; giant fans constantly pumped atmosphere down from the surface.

Finally, they reached the elevator station. Reuben had ordered the lift cage locked off here, on the 6,800-foot level—the mine's signage predated Canada's switch to the metric system. It was still waiting for them, no doubt to the chagrin of miners who wanted to come down or go up.

They entered the cage, and Reuben repeatedly activated the buzzer that would let the hoist operator on the surface know it was time to start the winch. The lift shuddered into motion. The cage had no internal lighting, and Reuben, Louise, and Paul had turned off their hardhat lamps rather than blind each other with their glare. The only illumination came in flashes from fixtures in the tunnels they passed every 200 feet, visible through the open front of the cage. In the weird, strobing light, Louise caught repeated glimpses of the strange man's angular features and his deep-set eyes.

As they went higher and higher, Louise felt her ears pop several times. They soon passed the 4,600-foot level, Louise's favorite. Inco grew trees there for reforestation projects around Sudbury. The temperature was a constant 20 degrees; adding artificial light turned it into a fabulous greenhouse.

Crazy thoughts occurred to Louise, weird *X-Files* notions about how the man could have gotten inside the sphere with the trapdoor still bolted shut. But she kept them to herself; if Paul and Reuben were having similar flights of fancy, they were also too embarrassed to give them voice. There *had* to be a rational explanation, Louise told herself. There had to be.

The cage continued its long ascent, and the man seemed to take stock of himself. His strange clothes were still somewhat wet, although the blowing air in the tunnels had done much to dry them. He tried wringing out his shirt, a few drops falling on the yellow-painted metal floor of the elevator cage. He then used his large hand to brush his wet hair off his forehead revealing, to Louise's astonishment—she gasped, although the sound surely was inaudible over the clanging of the rising car—a prodigious ridge arching above each eye, like a squashed version of the McDonald's logo.

At last the elevator shuddered to a halt. Paul, Louise, Dr. Montego, and the stranger disembarked, passing a small group of perplexed and irritated miners who were waiting to go down. The four of them headed up the ramp into the large room where workers hung their outdoor clothes each day, swapping them for coveralls. Two ambulance attendants were waiting. "I'm Reuben Montego," said Reuben, "the mine-site doctor. This man nearly drowned, and he's suffered a cranial trauma . . ." The two attendants and the doctor continued to discuss the man's condition as they hustled him out of the building and into the hot summer day.

Paul and Louise followed, watching as the doctor, the injured man, and the attendants entered the ambulance, and sped away on the gravel road.

"Now what?" said Paul.

Louise frowned. "I have to call Dr. Mah," she said. Bonnie Jean Mah was SNO's Director. Her office was at Carleton University in Ottawa, almost 500 kilometers away. She was rarely seen at the actual observatory site; the day-to-day operations were left to postdocs and grad students, like Louise and Paul.

"What are you going to tell her?" asked Paul.

Louise looked in the direction of the departing ambulance, with its impossi-

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ble passenger. *"Je ne sais pas,"* she said, shaking her head slowly.

Chapter 3

It had started *much* more serenely. "Healthy day," Ponter Boddit had said softly, propping his jaw up with a crooked arm as he looked over at Adikor Huld, who was standing by the washbasin.

"Hey, sleepyhead," said Adikor, turning now and leaning his muscular back against the scratching post. He shimmied left and right. "Healthy day."

Ponter smiled back at Adikor. He liked watching Adikor move, liked watching the muscles in his chest work. Ponter didn't know how he would have survived the loss of his woman-mate Klast without Adikor's support—although there were still some lonely times. When Two became One—the latest occurrence of which had just ended—Adikor went in to be with his own woman-mate and their child. But Ponter's daughters were getting older, and he'd hardly seen them this time. Of course, there were plenty of elderly women whose men had died, but women so full of experience and wisdom—women old enough to vote!—would want nothing to do with one as young as Ponter, who had seen only 447 moons.

Still, even if they didn't have much time for him, Ponter had enjoyed seeing his daughters, although—

It depended on the light. But sometimes, when the Sun was behind her, and she tilted her head just so, Jasmel was the absolute image of her mother. It took Ponter's breath away; he missed Klast more than he could say.

Across the room, Adikor was now filling the pool. He was bent over, operating the nozzle, his back to Ponter. Ponter lowered his head onto the disk-shaped pillow and watched.

Some people had cautioned Ponter against moving in with Adikor, and, Ponter was sure, a few of Adikor's friends had probably expressed a similar concern to him. It had nothing to do with what had transpired at the Academy; it was simply that working *and* living together could be an awkward combination. But although Saldak was a large city (its population was over twenty-five thousand, split between Rim and Center), there were only six physicists in it, and three of those were female. Ponter and Adikor both enjoyed talking about their work and debating new theories, and both appreciated having someone who really understood what they were saying.

Besides, they made a good pair in other ways. Adikor was a morning person; he hit the day running and enjoyed drawing the bath. Ponter rallied as the day progressed; he always looked after preparing the evening meal.

Water continued to spray from the nozzle; Ponter liked the sound, a raucous white noise. He let out a contented sigh and climbed out of the bed, the moss growing on the floor tickling his feet. He stepped over to the window and grasped the handles attached to the sheet-metal panel, pulling the shutter off the magnetic window frame. He then reached over his head, placing the shutter in its daytime position, adhering to a metal panel set in the ceiling.

The Sun was rising through the trees; it stung Ponter's eyes and he tilted his head down, bringing the front of his jaw to his chest, letting his browridge shade his vision. Outside, a deer was drinking from the brook three hundred paces away. Ponter hunted occasionally, but never in the residential areas; these deer knew they had nothing to fear—not here, not from any of the humans. Off in the distance, Ponter could see the glint of the solar panels spread along the ground by the next house.

Ponter spoke into the air. "Hak," he said, calling his Companion implant by the name he'd given it, "what's the forecast?"

"Quite lovely," said the Companion.

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"The high today: sixteen degrees; the low tonight, nine." The Companion used a feminine voice. Ponter had recently—and, he now realized, stupidly—reprogrammed it to use recordings of Klast's voice, taken from her alibi archive, as the basis for the way it spoke. He'd thought hearing the sound of her voice would make him feel less lonely, but instead it tugged at his heart every time his implant talked to him.

"No chance of rain," continued his Companion. "Winds from twenty-percent deasil, at eighteen thousand paces per daytenth."

Ponter nodded; the implant's scanners could easily detect him doing that.

"Bath's ready," said Adikor from behind him. Ponter turned and saw Adikor slipping into the circular pool recessed into the floor. He started the agitator, and the water roiled around him. Ponter—naked, like Adikor—walked over to the pool and slipped in as well. Adikor preferred his water warmer than Ponter did; they'd eventually settled on a compromise temperature of 37 degrees—the same as body temperature.

Ponter used a *golbas* brush and his hands to clean the parts of Adikor that Adikor himself couldn't reach, or preferred to have Ponter do. Then Adikor helped clean Ponter.

There was much moisture in the air; Ponter breathed deeply, letting it humidify his sinus cavities. Pabo, Ponter's large reddish-brown dog, came into the room. She didn't like to get wet, so she stayed several paces from the pool. But she clearly wanted to be fed.

Ponter gave Adikor a "what can you do?" look, and hauled himself out of the bath, dripping on the blanket of moss. "All right, girl," he said. "Just let me get dressed."

Satisfied that her message had been delivered, Pabo padded out of the bedroom. Ponter moved over to the washbasin and selected a drying cord. He gripped the two handles and rolled it from side to side across his back; he then chomped down on one of the cord's handles while he dried off his arms and legs. Ponter looked at himself in the square mirror above the washbasin, and used splayed fingers to make sure his hair was deployed properly on either side of his central part.

There was a pile of clean clothes in a corner of the room. Ponter walked over and surveyed the selection. He normally didn't think much about clothing, but if Adikor and he were successful today, one of the Exhibitionists might come look at them. He picked out a charcoal-gray shirt, pulled it on, and did up the clasps at the tops of the shoulders, closing the wide gaps. This shirt was a good choice, he thought—it had been a gift from Klast.

He selected a pant and put it on, slipping his feet into the baggy pouches at the end of each leg. He then cinched the leather ankle and instep ties, producing a comfortable snugness.

Adikor was getting out of the pool now. Ponter glanced at him, then looked down at the display on his own Companion. They really did have to get going; the hover-bus would be along shortly.

Ponter headed out into the main room of the house. Pabo immediately bounded over to him. Ponter reached down and scratched the top of the dog's head. "Don't worry, girl," he said. "I haven't forgotten you."

He opened the vacuum box and pulled out a large, meaty bison bone, saved from last night's dinner. He then set it on the floor—the moss overlain with glass sheets here to make cleanups easier—and Pabo began to gnaw at it. Adikor joined Ponter in the kitchen and set about fixing breakfast. He took two slabs of elk meat out of the vacuum box and put them in the laser cooker, which filled with steam to remoisturize the meat. Ponter glanced over, looking through the cooker's window, watching the ruby beams crisscrossing in intricate patterns, perfectly grilling every part of

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the steaks. Adikor filled a bowl with pine nuts and set out mugs of diluted maple syrup, then fetched the now-done steaks.

Ponter turned on the Voyeur, the square wall-mounted panel springing instantly to life. The screen was divided into four smaller squares, one showing transmissions from Hawst's enhanced Companion; another, those from Talok's; the lower-left, pictures of Gawlt's life; and the lower-right, images of Lulasm's. Adikor, Ponter knew, was a Hawst fan, so he told the Voyeur to expand that image to fill the entire screen. Ponter had to admit that Hawst was always up to something interesting—this morning, he'd headed to the outskirts of Saldak where five people had been buried alive by a rock slide. Still, if an Exhibitionist did come by the mineshaft entrance today, Ponter hoped it would be Lulasm; Ponter thought she usually asked the most insightful questions.

Ponter and Adikor both sat and put on dining gloves. Adikor scooped up some pine nuts from the bowl and sprinkled them over his steak, then pounded them into the meat with the palm of his gloved hand. Ponter smiled; it was one of Adikor's endearing quirks—he'd never met anyone else who did that.

Ponter picked up his own steak, still sizzling slightly, and bit a hunk off. It had that sharp tang one only tasted in meat that had never been frozen; how had anyone survived before vacuum storage had been invented?

A short time later, Ponter saw the hover-bus settle to the ground outside the house. He told the Voyeur to shut off, they tossed their dining gloves in the sonic cleanser, Ponter patted Pabo on the head, and he and Adikor went out the door, leaving it open so that Pabo could come and go as she pleased. They entered the hover-bus, greeting the seven other passengers already on board, and headed off to work as if it were just another ordinary day.

* * *

Chapter 4

Ponter Boddit had grown up in this part of the world; he'd been aware of the nickel mine his whole life. Still, he'd never met anyone who had visited its depths; the mining was done exclusively by robots. But when Klast had been diagnosed with leukemia, Ponter and she had begun to meet with others suffering from cancers—for support, for companionship, and to share information. They met in a *kobalant* facility, which, of course, was vacant in the evenings.

Ponter had expected several of the others who were afflicted to have visited the mine. After all, by going deep in the rocks, they surely would have been exposed to abnormally high radioactivity.

But no one who had gone down the mine was part of their group. Ponter started asking around and discovered that this was a very unusual nickel mine; the background radiation levels in its ancient granites were extraordinarily low.

And, because of that, an idea occurred to him. He was a physicist, working with Adikor Huld on building quantum computers. But the quantum registers were enormously sensitive to outside disturbances; they'd had a real problem with cosmic rays provoking decoherence.

The solution, it seemed, was right beneath their feet. With a thousand armspans of rock over their heads, cosmic rays would no longer pose a problem. At that depth, nothing short of neutrinos could penetrate, and they wouldn't affect the experiments Ponter and Adikor wanted to run.

Delag Bowst was Saldak's chief administrator; the position had been forced upon him by the Grays. But, of course, it was always that way with administrators: no one who would choose such a contribution was suited to make it.

Ponter had presented his proposal to

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Bowst: let him build a quantum-computing facility deep inside the mine. And Bowst had convinced the Grays to agree. A technological civilization could not exist without metals, after all, but the mine had not always been friendly to the environment. Any opportunity to do something positive was welcomed.

And so the computing facility had been built. Ponter and Adikor were still having problems with an unexpected source of decoherence: piezoelectric discharges caused by the stresses on the rocks at such great depths. But Adikor felt he'd now solved that problem, and today they would try again, factoring a number bigger than any ever done before.

The hover-bus dropped Ponter and Adikor off at the entrance to the mine. It was a beautiful summer day, with a bright blue sky, just as Ponter's Companion implant had promised. Ponter could smell pollens in the air and hear the plaintive calls of loons on the lake. He picked up a head protector from the storage shed, and attached it to his shoulders, the two struts holding a flat shelf above his skull; Adikor put on his own head protector.

The elevator at the mine entrance was cylindrical. The two physicists got into the car, and Ponter tapped the activation switch with his foot.

The lift started its long descent.

Ponter and Adikor left the elevator and headed down the lengthy drift toward the quantum-computing lab; naturally, it had been built in a part of the mine that had yielded no valuable ores. They walked in silence, the easy, companionable silence of two men who had known each other for ages.

Finally, they reached the quantum-computing facility. It consisted of four rooms. The first was a tiny cubicle for eating; it wasn't worth taking the time to ride the elevator all the way back up to the surface for meals. The second was a dry toilet facility; there was no plumbing down here, so the waste had to be hauled out at the end of each day. The third was the control room, containing instrument clusters and work tables. And the fourth, the only large room, was the giant computing chamber, bigger than all the rooms combined in the house that Ponter and Adikor shared.

The usual goal in building computers was to make them as small as possible: that kept delays caused by the speed of light to a minimum. But Ponter and Adikor's quantum-computer array was based on using quantally entangled protons as registers, and there had to be a way to distinguish between reactions that were occurring simultaneously, because of the entanglement, and those that were occurring due to normal speed-of-light communication between two protons. And the simplest way to do that was by putting some distance between each register, so that the time it would take for light to travel between two registers was easily measurable. The protons were therefore held in place inside magnetic-containment columns spaced throughout the chamber.

Ponter and Adikor removed their head protectors and entered the control room. Adikor was the practical one; he found ways to implement Ponter's ideas in software and hardware. He settled in at a console and began going through the routines required to initialize the quantum-computing array. "How long until we're ready?" asked Ponter.

"Another half-tenth," said Adikor. "I'm still having trouble stabilizing register 69."

"Do you think it's going to work?" asked Ponter.

"Me?" said Adikor. "Sure." He smiled. "Of course, I said that yesterday and the day before and the day before that."

"The perpetual optimist," said Ponter.

"Hey," said Adikor, "when you're this far down, there's nowhere to go but up."

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Ponter laughed, then walked through the archway into the eating room to get a squeeze tube of water. He hoped the experiment would indeed succeed today. The next Gray Council was coming up soon, and he and Adikor would have to explain again what they were giving back to the community through their work. Scientists usually got their proposals approved—everyone could clearly see how science had bettered their lives—but, still, it was always more satisfying to report positive results.

Ponter used his teeth to pull open the plastic tab on the tube of water, and gulped some of the cool liquid. He then moved back into the control room, sat at his desk, and started reading through a fan of pale-green sheets of square plastic, reviewing the notes from their last attempt, occasionally taking sips of his water. Ponter's back was to Adikor, who was fiddling with controls on the opposite side of the small room. The main wall of the room was mostly glass, a big window looking out over the large computing chamber, which had both a higher ceiling and a lower floor than the other rooms.

They'd already had considerable success with their quantum computer. Last tenmonth, they had factored a number that required 10^{73} hydrogen atoms as registers—a quantity vastly greater than all the hydrogen in all the stars in this entire galaxy, and sixty-odd orders of magnitude greater than the capacity of the entire computing chamber, even if it had been filled entirely with hydrogen. The *only* way they could have succeeded was if they really were getting true quantum-computing effects—having their limited number of physical registers existing simultaneously in multiple states superimposed one upon the other.

In a way, this next experiment was merely incremental: it was an attempt to factor an even bigger number. But the number in question was one of the vastly huge ones that Digandal's theorem said should be prime. No conventional computer could test that, but their quantum computer should be able to do so.

Ponter checked a few more pages of the printout, then went over to another control cluster and pulled some operational buds, adjusting parts of the recording system. He wanted to make sure that every facet of the run would be recorded, so that there could be no doubt afterward about the result. If they could just—

"Ready," said Adikor.

Ponter felt his heart begin to race. He so much wanted it to work—both for his own sake, and for Adikor's, too. Ponter had had much luck early in his career; his was a respected name in physics circles. Even if he were to die today, he would be long remembered. Adikor hadn't been as successful, Ponter knew, although he surely deserved to be. How wonderful it would be for both of them if they could prove—or disprove; either result would be significant—Digandal's theorem.

There were two control clusters to be operated, one on each side of the small room. Ponter stayed at the one he was now at, next to the arch leading to the eating room; Adikor moved over to the other one on the opposite side of the room. All the controls should have been localized in one place, but this setup had saved almost thirty arm-spans worth of the expensive quantally transductive cable used to link the registers. Each control cluster was mounted on a wall. Adikor stood next to his and pulled the buds that needed pulling. Ponter, meanwhile, was operating the appropriate controls on his own cluster.

"All set?" asked Adikor.

Ponter looked at the series of indicator lights on his board; they were all red, the color of blood, the color of health. "Yes."

Adikor nodded. "Ten beats," he said, starting the countdown. "Nine. Eight. Seven. Six. Five. Four. Three. Two. One.

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Zero."

Several lights flashed on Ponter's board, showing that the registers were working. In theory, over the span of a fraction of a beat, all the possible factors had been tried, and the results had already been received as a series of interference patterns on photographic film. It would take the conventional computer that decoded the interference patterns a while to compose the list of factors—which, if Digandal was wrong and this number wasn't prime, could be a very large list indeed.

Ponter left his console and moved to sit down. Adikor paced back and forth, looking out the window at the rows of register tanks, each a sealed glass-and-steel column containing a specific amount of hydrogen.

Finally, the conventional computer made a *plunk* sound, signaling that it had finished.

There was a monitor square in the center of Ponter's control cluster; the results appeared on it in black glyphs on a yellow background. And the results were—

"Gristle!" swore Adikor, standing behind Ponter, a hand on his shoulder.

The display read: "Error in register 69; factoring aborted."

"We have *got* to get that one replaced," said Ponter. "It's given us nothing but trouble."

"It's not the register," said Adikor. "It's the base that holds it to the floor. But it'll take tendays to get a new one made."

"So we can't do anything before the Gray Council?" asked Ponter. He didn't look forward to facing the elder citizens and saying that nothing had been added to our knowledge since the last Council session.

"Not unless . . ." Adikor trailed off.

"What?"

"Well, the problem with 69 is that it tends to vibrate on its base; the attachment clamps weren't machined quite right. If we could find something to anchor it with . . ."

Ponter scanned the room. There was nothing that looked suitable. "How about if I just go out on the computing floor and lean on it? You know, press down with all my weight. Wouldn't that keep it from vibrating?"

Adikor frowned. "You'd have to hold it very steady. The equipment can tolerate some movement, of course, but . . ."

"I can do it," said Ponter. "But—but will my presence on the computing floor promote decoherence?"

Adikor shook his head. "No. The register columns are heavily shielded; it would take something a lot more radioactive or electrically noisy than a human body to upset the contents."

"Well, then?"

Adikor frowned again. "It's hardly an elegant solution to the problem."

"But it might work."

Adikor nodded. "I suppose it's worth a try. Better than going to Council empty-handed."

"All right!" said Ponter, decisively. "Let's do it." Adikor nodded, and Ponter opened the door that separated the other three rooms from the large chamber containing the register tanks. He then walked down the steps to the room's polished granite floor, which had been leveled with laser beams. Ponter moved carefully along it; he'd slipped once before while crossing. When he got to cylinder 69, he placed one hand on its curved top, covered that with his other hand, and then pressed down with all his strength. "Any time you're ready," Ponter shouted.

"Ten," Adikor shouted back. "Nine. Eight. Seven."

Ponter fought to keep his hands steady. As far as he could tell, the cylinder wasn't vibrating at all.

"Six. Five. Four."

Ponter took a deep breath, trying to calm himself. He held it in.

"Three. Two. One."

Here we go, thought Ponter.

"Zero!"

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Adikor heard the glass rattle fiercely in the window looking over the computing floor. "Ponter!" he shouted. Adikor hurried to the window. "P-Ponter?"

But there was no sign of him.

Adikor pulled the grip that unlatched the door, and—

Whoosh!

The door swung forward, flying open, the grip wrenched from Adikor's hand as a great rush of air from the control room flew past him out into the computing chamber; it was almost enough to tumble Adikor face first down the small staircase. Air was rushing *into* the computing chamber from the control room and the mine beyond as if—as if somehow the air that had been in there earlier had all been sucked away. Adikor's ears popped repeatedly.

"Ponter!" he called again once the wind had died down, but although the room was large, the register tanks, arrayed in a vast grid, were all narrow columns; there was no way Ponter could be concealed behind one of them.

What could have happened? If a rock wall elsewhere in the mine had collapsed, and behind it had been an area of low pressure, maybe . . .

But there were seismic sensors throughout the mining complex, and they'd have triggered the release of warning smells here in the computing lab if there had been any such disturbance.

Adikor hurried across the granite floor. "Ponter!" he called again. "Ponter?"

There was no fissure in the flooring; he couldn't have been swallowed up by the ground. Adikor could see register tank 69, the one Ponter had been working on, at the far end of the room. Ponter obviously wasn't there, but Adikor ran over to the register, anyway, looking for any clue, and—

Gristle!

Adikor found his feet going out from under him, and he came slamming down on his back on the granite floor. The surface was covered with water—lots of water. Where had it come from? Ponter had been drinking from a tube earlier, but Adikor was sure he'd finished it upstairs. And besides, there was much more here than could have fit in a tube; there were buckets of it, spreading out in a wide puddle.

The water—if that's what it was—looked clean, clear. Adikor brought his wet palm up to his face, sniffed. No odor.

A tentative lick.

No taste at all.

It *was* pure, apparently. Pure, clean water.

Heart pounding, head racing, Adikor went to get some containers to collect it in; it was the only clue he had.

Where had the water possibly come from?

And where on Earth had Ponter gone?

Chapter 5

What the—?

Absolute blackness.

And—water! Ponter Boddit's legs were wet, and—

And he was sinking, water up to his waist, his chest, the bottom of his jaw.

Ponter kicked violently.

His eyes were indeed wide open, but there was nothing—absolutely nothing—to be seen.

He flailed with his arms while treading water. He gulped in air.

What had happened? Where could he be?

One moment he'd been standing in the quantum-computing facility, and the next—

Darkness—so unrelentingly dark, Ponter thought perhaps he was blind. An explosion could have done that; rock bursts were always a danger this far underground, and—

And an influx of subterranean water *was* possible. He swung his arms some

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more, then stretched out his toes, trying to feel for the bottom, but—

But there was nothing, nothing at all. Just more water. He could be a handspan from the bottom, or a thousand times that much. He thought about diving down to find out, but in the dark, floating freely, with no light at all, he might lose track of which way was up and not make it back to the surface in time.

He'd taken in a mouthful of water as he'd felt for the bottom. It was utterly free of taste; he'd have expected a subterranean river to be brackish, but this seemed as pure as meltwater.

He continued to gulp air. His heart was racing, and—

And he wanted to swim toward the edge, wherever that—

A groaning sound, low, deep, from all around him.

Again, like an animal awakening, like . . .

Like something under great stress?

He finally had enough air in his lungs to manage a shout. "Help!" Ponter called. "Help!"

The sound echoed weirdly, as if he were in an enclosed space. Could he still be in the computing room? But, if he were, why wasn't Adikor responding to his calls?

He couldn't just stay there. Although he wasn't exhausted yet, he soon would be. He needed to find a surface to clamber on to, or something in the water with him that he could use as a flotation aid, and—

The groaning again, louder, more insistent.

Ponter started to dog paddle. If only there were some light—any light. He swam for what seemed a short distance, and—

Agony! Ponter banged his head into something hard. He switched back to treading water, his limbs beginning to ache, and he reached out with one hand, fingers splayed, palm forward. Whatever he had hit was hard and warm—not metal or glass, then. And it was absolutely smooth, maybe slightly concave, and—

Another groan, coming from—

His heart fluttered; he felt his eyes go wide, but they saw nothing at all in the blackness.

—coming from the hard wall in front of him.

He began to swim in the opposite direction, the noise now growing to earsplitting proportions.

Where was he? Where was he?

The volume continued to increase. He swam farther and—

Ouch! That hurt!

He'd slammed into another hard, smooth wall. These certainly weren't the walls in the quantum-computing chamber; those were covered with soft sound-deadening fabric.

Whoooooosbhhh!

Suddenly, the water around Ponter was moving, rushing, roaring, and he was caught up in it, as if he were in a raging river. Ponter took a huge breath, drawing some water in with the air, and then—

And then he felt something hard smash into the side of his head, and, for the first time since this madness began, he saw light: stars before his eyes.

And then, the blackness again, and silence, and—

Nothing more.

Adikor Huld walked back up to the control room, shaking his head in astonishment, in disbelief.

Ponter and he had been friends for ages; they were both 145s, and had first met as students at the Science Academy. But in all that time, he'd never known Ponter to be given to practical jokes. And, besides, there was no place he could be hiding. Fire safety required multiple exits from a room on the surface, but down here practicality made that impossible. The only way out was by walking through the control room. Some computing facilities had false floors to conceal cabling, but here the

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cabling was out in the open, and the floor was ancient granite, polished smooth.

Adikor had been watching the controls; he hadn't been looking out the window at the computing chamber. Still, there had been no flash of light to catch his eye. If Ponter had been—well, what? Vaporized? If he'd been vaporized, surely there should have been a smell of smoke or a tinge of ozone in the air. But there was nothing. He was simply *gone*.

Adikor collapsed into a chair—Ponter's chair—stunned.

He didn't know what to do next; he literally had no idea. It took several beats for him to focus his thoughts. He should notify the town's administrative office that Ponter was missing; get them to organize a search. It was conceivable—barely—that the ground had opened up, and Ponter had fallen through, maybe into another drift, another level of the mine. In which case he might be injured.

Adikor got to his feet.

Dr. Reuben Montego, the two ambulance attendants, and the injured man entered through the sliding glass doors to Emergency Admitting at St. Joseph's Health Centre, part of the Sudbury Regional Hospital.

The E.R.'s casualty officer turned out to be a Sikh in his mid-fifties with a jade-green turban. "What is it that is wrong?" he asked.

Reuben glanced down at the man's nametag, which read N. SINGH, M.D. "Dr. Singh," he said, "I'm Reuben Montego, the site doctor at the Creighton Mine. This man here almost drowned in a tank of heavy water, and, as you can see, he's suffered a cranial trauma."

"Heavy water?" said Singh. "Where would you—"

"At the neutrino observatory," said Reuben.

"Ah, yes," replied Singh. He turned and called for a wheelchair, then looked back at the man and started making notes on a clipboard. "Unusual body form," he said. "Pronounced supraorbital ridge. Very muscular, very broad shouldered. Short limbs. And—hello!—what is this, then?"

Reuben shook his head. "I don't know. It seems to be implanted in his skin."

"Very strange," said Singh. He looked at the man's face. "How do you feel?"

"He doesn't speak English," said Reuben.

"Ah," said the Sikh. "Well, his bones will talk for him. Let's get him into Radiology."

Reuben Montego paced back and forth in the emergency department, occasionally speaking to a passing doctor he happened to know. At last, Singh got word that the x-rays were ready. Reuben was hoping to be invited along, out of professional courtesy, and Singh did indeed beckon for him to follow.

The injured man was still in the x-ray room, presumably in case Singh decided to order more pictures. He was seated now in his wheelchair, looking more frightened, Reuben thought, than even a small child usually did in a hospital. The radiology technician had clipped the man's x-rays—a front view and a lateral shot—to a lighted wall panel, and Singh and Reuben moved over to examine them.

"Will you look at that?" said Reuben softly.

"Remarkable," said Singh. "Remarkable."

The skull was long—much longer than a normal skull, with a rounded protrusion at the back, almost like a hair bun. The doubly arched browridge was prominent and the forehead low. The nasal cavity was gigantic, with strange triangular projections pointing into it from either side. The huge mandible, visible at the bottom of the frame, revealed what the beard had hidden: the complete lack of a chin. It also showed

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a gap between the last molar and the rest of the jaw.

"I've never seen anything like it," said Reuben.

Singh's brown eyes were wide. "I have," he said. "I have." He turned to look at the man, who was still sitting in the wheelchair, babbling gibberish. Then Singh consulted the ghostly gray images again. "It is impossible," said the Sikh. "Impossible."

"What?"

"It cannot be . . ."

"What? Dr. Singh, for God's sake—"

Singh raised his hand. "I do not know how it can be thus, but . . ."

"Yes? Yes?"

"This patient of yours," said Singh, in a voice full of wonder, "appears to be a Neanderthal."

Chapter 6

"Good night, Professor Vaughan."

"Good night, Daria. See you tomorrow." Mary Vaughan glanced at the clock; it was now 8:55 P.M. "Be careful."

The young grad student smiled. "I will." And she headed out of the lab.

Mary watched her go, remembering wistfully when her own figure had been as slim as Daria's. Mary was thirty-eight, childless, and long separated from her husband.

She went back to poring over the autoradiograph film, reading off nucleotide after nucleotide. The DNA she was studying had been recovered from a passenger pigeon mounted at the Field Museum of Natural History; it had been sent here, to York University, to see whether it could be completely sequenced. Previous attempts had been made, but the DNA had always been too degraded. But Mary's lab had had unprecedented success reconstructing DNA that other facilities couldn't read.

Sadly, though, the sequence broke down; there was no way to determine from this sample what string of nucleotides had originally been present. Mary rubbed the bridge of her nose. She would have to extract some more DNA from the pigeon specimen, but she was too tired to do that tonight. She looked at the wall clock; it was now 9:25.

That wasn't too late; many of the university's summer evening classes got out at 9:00, so there should still be lots of people milling about. If she worked past 10:00 P.M., she usually called for someone from the campus walking service to escort her to her car. But, well, it didn't really seem necessary this early in the evening. Mary removed her pale-green lab coat and hung it on the rack by the door. It was August; the lab was air conditioned, but it was surely still quite warm out. Another sticky, uncomfortable night lay ahead.

Mary shut off the lights in the lab; one of the fluorescents strobed a bit as it died. She then locked the door and made her way down the second-floor corridor, past the Pepsi machine (Pepsi had paid York University two million dollars to become the exclusive soft-drink vendor on campus).

The corridor was lined with the usual bulletin boards, announcing faculty openings, classroom assignments, club meetings, come-ons for cheap credit cards and magazine subscriptions, and all sorts of items for sale by students and faculty, including one poor clown hoping to get someone to pay him money for an old electric typewriter.

Mary continued down the corridor, her heels clicking against the tiles. No one else was in the hallway. She did hear the sound of the urinals flushing as she passed the men's room, but that happened automatically, governed by a timer.

The door to the stairwell had safety-glass windows, with wire mesh embedded in them. Mary pushed open the door and headed down the four flights of concrete steps, each flight taking her a half-story lower. On the ground floor she left the stairwell and continued a short distance down another corridor, this one also empty except for a janitor

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working at the far end. She walked into the entryway, passing distribution boxes for the campus paper, *The Excalibur*, and, at last, headed out through the double doors into the warm night air.

The Moon wasn't up yet. Mary headed along the sidewalk, passing a few students as she did so, although none she recognized. She swatted at the occasional insect, and—

A hand clamped down over her mouth, and she felt something cold and sharp against her throat. "Don't make a sound," said a deep, raspy voice, pulling her backward.

"Please—" said Mary.

"Be quiet," the man said. He was continuing to pull her back, the knife pressing sharply into her throat. Mary's heart pounded violently. The hand over her mouth came off, and she felt it again a moment later on her left breast, squeezing roughly, painfully.

He'd pulled her into a small alcove, two concrete walls meeting at a right angle, a maple blocking most of the view. He then spun her around, pinning her arms against the wall, his left hand still holding the knife even as it also gripped her wrist. She could see him now. He was wearing a black balaclava, but he was clearly a white man—rings of his skin were visible around his blue eyes. Mary tried to bring her knee up into his groin, but he arched backward, and all she managed was a glancing contact.

"Don't fight me," said the voice. She smelled tobacco on his breath, and could feel that his palms were sweaty against her wrists. The man pulled his arm away from the wall, yanking Mary's with it, then he slammed both their arms back against the concrete so that the knife was closer to Mary's face. His other hand found the front of his own pants, and Mary could hear the sound of a zipper. She felt acid at the back of her throat.

"I've—I've got AIDS," said Mary, scrunching her eyes closed, trying to shut everything out.

The man laughed, a sandpapery, humorless sound. "That makes two of us," he said. Mary's heart skipped, but he was probably lying, too. How many women had he done this to? How many had tried the same desperate gambit?

There was a hand now on the waist of her pants, pulling down. Mary felt her zipper parting, and her pants coming down around her hips, and his pelvis and his rock-hard erection grinding against her panties. She let out a yelp and the man's hand was suddenly on her throat, squeezing, nails biting into her flesh. *"Quiet, bitch."*

Why didn't someone come by? Why was there no one around? God, why did—

She felt a hand yank down her panties, then felt his penis against her labia. He rammed it into her vagina. The pain was excruciating; if felt as though things were ripping down there.

It's not about sex, thought Mary, even as tears welled from the corners of her eyes. *It's a crime of violence.* The small of her back slammed against the concrete wall, as the man smashed his body against hers, ramming himself deep into her, again and again and again, his animal grunts growing louder with each thrust.

And then, at last, it was over. He pulled out. Mary knew she should look down, look for any identifying details, look even to see whether he was circumcised, anything that might help convict the bastard, but she couldn't bear to look at it, at him. She tilted her head up at the dark sky, everything blurred through stinging tears.

"Now, you just stay here," said the man, tapping her cheek with a flat side of the knife. "You don't say a word, and you stay here for fifteen minutes." And then she heard the sound of a zipper going up, and the man's footfalls as he ran away across the grass-covered ground.

Mary leaned back against the wall and slid down to the concrete sidewalk, her

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knees coming up to her chin. She hated herself for the wracking sobs that escaped from her.

After a while, she put a hand down between her legs, then pulled it away and looked at it to see if she was bleeding; she wasn't, thank God.

She waited for her breathing to calm down, and for her stomach to settle enough that she thought she could rise to her feet without vomiting. And then she did get up, painfully, slowly. She could hear voices—women's voices—off in the distance, two students chatting and laughing as they went along. Part of her wanted to call out to them, but she couldn't force the sound out of her throat.

She knew it was maybe twenty-five Celsius out, but she felt cold, colder than she'd ever been in her life. She rubbed her arms, warming herself.

It took—who knew? Five minutes? Five hours?—for her to recover her wits. She should find a phone, dial 911, call the Toronto police . . . or the campus police, or—she knew about it, had read about it in campus handbooks—the York University rape-crisis center, but . . .

But she didn't want to talk to anyone, to see anyone—to . . . to have anyone see her like this.

Mary closed her pants, took a deep breath, and started walking. It was a few moments before she was conscious of the fact that she wasn't heading on toward her car, but rather was going back toward the Farquharson Life Sciences Building.

Once she got there, she held the banister all the way up the four half-flights of stairs, afraid of letting go, afraid of losing her balance. Fortunately, the corridor was just as deserted as it had been before. She made it back into her lab without being seen by anyone, the fluorescents spluttering to life.

She didn't have to worry about being pregnant. She'd been on the pill—not a sin in her view, but certainly one in her mother's—ever since she'd married Colm, and, well, after the separation, she'd kept it up, although there had turned out to be little reason. But she *would* find a clinic and get an AIDS test, just to be on the safe side.

Mary wasn't going to report it; she had already made up her mind about that. How many times had she cursed those she'd read about who had failed to report a rape? They were betraying other women, letting a monster get away, giving him a chance to do it again to someone else, to—to *her*, now, but—

But it was easy to curse when it wasn't you, when you hadn't been there.

She knew what happened to women who accused men of rape; she'd seen it on TV countless times. They'd try to establish that it was *her* fault, that she wasn't a credible witness, that somehow she had consented, that her morals were loose. *"So, you say you're a good Catholic, Mrs. O'Casey—oh, I'm sorry, you don't go by that name anymore, do you? Not since you left your husband Colm. No, it's* Ms. *Vaughan now, isn't it? But you and Professor O'Casey* are *still legally married, aren't you? Tell the court, please, have you slept with other men since you abandoned your husband?"*

Justice, she knew, was rarely found in a courtroom. She would be torn apart and reassembled into someone she herself wouldn't recognize.

And, in the end, nothing would likely change. The monster would get away.

Mary took a deep breath. Maybe she'd change her mind at some point. But the only thing that was really important right now was the physical evidence, and she, Professor Mary Vaughan, was at least as competent as any policewoman with a rape kit at collecting that.

The door to her lab had a window in it; she moved so that she couldn't possibly be seen by anyone passing by in the corridor. And then she undid her pants, the sound of her own zipper causing her heart to jump. She then got a glass

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specimen container and some cotton swabs, and, blinking back tears, she collected the filth that was within her.

When she was done, she sealed the specimen jar, wrote the date on it in red ink, and labeled it "Vaughan 666," her name and the appropriate number for such a monster. She then sealed her panties in an opaque specimen container, labeled it with the same date and designation, and put both containers in the fridge in which biological specimens were stored, placing them alongside DNA taken from a passenger pigeon and an Egyptian mummy and a woolly mammoth.

Chapter 7

"Where am I?" Ponter knew his voice sounded panicky, but, try as he might, he couldn't control it. He was still seated in the odd chair that rolled on hoops, which was a good thing, because he doubted he'd be very steady on his feet.

"Calm down, Ponter," said his Companion implant. "Your pulse is up to—"

"Calm down!" snapped Ponter, as if Hak had suggested a ridiculous impossibility. *"Where am I?"*

"I'm not sure," said the Companion. "I'm picking up no signals from the positioning towers. In addition, I'm cut off entirely from the planetary information network, and am receiving no acknowledgment from the alibi archives."

"You're not malfunctioning?"

"No."

"Then—then this can't be Earth, can it? You'd be getting signals if—"

"I'm sure it *is* Earth," said Hak. "Did you notice the Sun while they brought you over to that white vehicle?"

"What about it?"

"Its color temperature was 5,200 degrees, and it subtended one-seven-hundredth of the celestial sphere—just like Sol as seen from Earth's orbit. Also, I recognized most of the trees and plants I saw. No, this is clearly the surface of the Earth."

"But the stench! The air is foul!"

"I'll have to take your word for that," said Hak.

"Could we have—could we have traveled in time?"

"That seems unlikely," replied the Companion. "But if I can see the constellations tonight, I will be able to tell if we've moved forward or backward an appreciable amount. And if I can spot some of the other planets and the phase of the Moon, I should be able to figure the exact date."

"But how do we get back home? How do we—"

"Again, Ponter, I must exhort you to calm down. You are close to hyperventilating. Take a deep breath. There. Now let it out slowly. That's right. Relax. Another breath—"

"What are those *creatures?"* said Ponter, waving a hand at the scrawny figure with dark-brown skin and no hair and the other scrawny figure with lighter skin and a wrapping of fabric around his head.

"My best guess?" said Hak. "They are Gliksins."

"Gliksins!" exclaimed Ponter, loud enough that the two strange figures turned to look at him. He lowered his voice. "Gliksins? Oh, come *on* . . ."

"Look at those skull images over there." Hak was speaking to Ponter through a pair of cochlear implants, but by changing the left-right balance of his voice he could indicate a direction as surely as if he had pointed. Ponter got up—shakily—and crossed the room, heading away from the strange beings and approaching an illuminated panel like the one they were looking at, with several deepviews of skulls clipped to it.

"Green meat!" said Ponter, looking at the strange skulls. "They *are* Gliksins—aren't they?"

"I would say so. No other primate has that lack of browridge, or that projection from the front of the lower jaw."

"Gliksins! But they've been extinct for—well, for how long?"

"Perhaps 400,000 months," said Hak.

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"But this *can't* possibly be Earth of that long ago," said Ponter. "I mean, there's no way the civilization we've seen would have failed to leave traces in the archeological record. At best, Gliksins chipped stone into crude choppers, right?"

"Yes."

Ponter tried to keep from sounding hysterical. "So, again, where *are* we?"

Reuben Montego looked agape at the casualty officer, Dr. Singh. "What do you mean, 'He appears to be a Neanderthal'?"

"The skull features are absolutely diagnostic," said Singh. "Believe me: I've got a degree in craniology."

"But how can that be, Dr. Singh? Neanderthals have been extinct for millions of years."

"Actually, only for twenty-seven thousand years or so," said Singh, "if you accept the validity of some recent finds. If those finds prove spurious, then they died out thirty-five thousand years ago."

"But then how . . ."

"That I do not know." Singh waved his hand at the x-rays clipped to the illuminated panel. "But the suite of characters visible here is unmistakable. One or two might happen in any given modern *Homo sapiens* skull. But all of them? Never."

"What characters?" asked Reuben.

"The browridge, obviously," said Singh. "Note that it is unlike other primate browridges: it is doubly arched, and has a sulcus behind it. The way the face is drawn forward. The prognathism—just look at that jaw jut out! The lack of a chin. The retromolar gap"—he pointed to the space behind the last tooth. "And see those triangular projections into the nasal cavity? Those are found in no other mammal, let alone any other primate." He tapped the image of the skull's rear. "And see this rounded projection at the back? That is called the occipital bun; again, it's distinctly Neanderthaloid."

"You're pulling my leg," said Reuben. "This is something I would never do."

Reuben looked back at the stranger, who had gotten up out of the wheelchair and was now staring, with astonishment, at a couple of skull x-rays on the other side of the room. Reuben then looked again at the x-ray film in front of him. Both he and Singh had been out of the room when the technician had taken the pictures; it was possible that, for whatever reason, someone had substituted different shots, although—

Although these *were* real x-rays, and they were x-rays of a living head, not a fossil: nasal cartilage and the outline of flesh were clearly visible. Still, there was something very strange about the lower jaw. Parts of it showed as a much lighter shade of gray in the x-ray, as if they were made of a less-dense material. And those parts were smooth, featureless, as though the material was uniform in composition.

"It's a fake," said Reuben, pointing to the anomalous part of the jaw. "I mean—*he's* a fake; he's had plastic surgery to make himself look Neanderthal."

Singh squinted at the x-ray. "There is reconstructive work here, yes—but only in the mandible. The cranial features all seem to be natural."

Reuben glanced at the injured man, who was still looking at other skull x-rays while babbling to himself. The doctor tried to imagine the stranger's skull beneath his skin. Would it have looked like the one Singh was now showing him?

"He has several artificial teeth," said Singh, still studying the x-ray. "But they're all attached to the section of jaw that has been reconstructed. As for the rest of the teeth, they seem natural, although the roots are taurodontid—another Neanderthaloid trait."

Reuben turned back to the x-ray. "No cavities," he said, absently.

"That is right," said Singh. He took a moment to assess the x-rays. "In any

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event, he seems to have no subdural hematoma, nor any skull fracture. There is no reason to keep him in hospital."

Reuben looked at the stranger. Who the hell could he be? He babbled in some strange tongue, and he'd had extensive reconstructive surgery. Could he be a member of some bizarre cult? Was that why he'd broken into the neutrino observatory? It made a certain amount of sense, but—

But Singh *was* right; except for the mandibular restoration, what they were seeing in the x-ray was a natural skull. Reuben Montego crossed the room slowly, warily, as if—Reuben realized within a few moments what he was doing: he was approaching the stranger not as one would approach another human being, but rather as one might come near a wild animal. And yet there had been nothing in his manner so far to suggest anything except civility.

The man clearly heard Reuben approaching. He took his attention away from the x-rays he'd been captivated by and turned to face the doctor.

Reuben stared at the man. He had noted earlier that his face was strange. The browridge, arching above each eye, was obvious. His hair was parted precisely in the middle, not at either side, and it looked like that was the natural part, not some affectation. And the nose: the nose was huge—but it wasn't the least bit aquiline. In fact, it wasn't quite like any other nose Reuben had ever seen before; it completely lacked a bridge.

Reuben lifted his right hand slowly, fingers gently spread, making sure the gesture looked tentative, not threatening. "May I?" he said, moving his hand closer to the stranger's face.

The man might not have understood the words, but the intent of the gesture was obvious. He tilted his head forward, inviting the touch. Reuben ran his fingers along the browridge; over his forehead, along the length of the skull from front to back, feeling the—what had Singh called it?—the occipital bun at the rear, a hard dome of bone beneath the skin. There was no doubt at all: the skull shown in the x-rays belonged to this person.

"Reuben," said Dr. Montego, touching his own chest. "Roo-ben." He then gestured at the stranger with an upturned palm.

"Ponter," said the stranger, in a deep, sonorous voice.

Of course, the stranger might be taking "Reuben" to be the term for Montego's kind of humanity, and "Ponter" might be the stranger's word for Neanderthal.

Singh moved over to join them. "Naonihal," he said—revealing what the *N* stood for on his nametag. "My name is Naonihal."

"Ponter," repeated the stranger. Other interpretations were still possible, thought Reuben, but it did seem likely that was the man's name.

Reuben nodded at the Sikh. "Thank you for your help." He then turned to Ponter and motioned for him to follow. "Come on."

The man moved toward the wheelchair.

"No," said Reuben. "No, you're fine."

He gestured again for him to follow, and the man did so, on foot. Singh unclipped the x-rays, put them in a large envelope, and walked out with them, heading back to Emergency Admitting.

Frosted glass doors blocked the way ahead. As Singh stepped on the rubber mat in front of the doors, they slid aside, and—

Electronic flashes exploded in their faces.

"Is this the guy who blew up SNO?" called a male voice.

"What charges are Inco going to lay?" asked a female one.

"Is he injured?" called another male.

It took a few moments for Reuben to digest the scene. He recognized one man as a correspondent for the local CBC station, and another was the min-

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ing-affairs reporter for the Sudbury *Star*. The dozen other people crowding around he didn't know, but they were shoving microphones forward that bore the logos of Global Television, CTV, and Newsworld, and the call letters of local radio stations. Reuben looked at Singh and sighed, but he supposed this had been inevitable.

"What's the suspect's name?" shouted another reporter.

"Does he have any prior record?"

The reporters continued to snap pictures of Ponter, who was making no effort to hide his face. At that moment, two RCMP officers entered from outside, wearing dark-blue police uniforms. "Is this the terrorist?"

"Terrorist?" said Reuben. "There's no evidence of that."

"You're the mine-site doctor, aren't you?" said one of the cops.

Reuben nodded. "Reuben Montego. But I don't believe this man is a terrorist."

"But he blew up the neutrino observatory!" declared a reporter.

"The observatory was damaged, yes," said Reuben, "and he was there when it happened, but I don't believe he intended it. After all, he almost drowned himself."

"Irregardless," said the cop, causing Montego to immediately lower his opinion of him, "he will have to come with us."

Reuben looked at Ponter, at the reporters, then back at Singh. "You know what happens in cases like this," he said softly to the Sikh. "If the authorities take Ponter away, no one will ever see him again."

Singh nodded slowly. "So one might assume."

Reuben chewed his lower lip, thinking. Then he took a deep breath and spoke loudly. "I don't know where he came from," said Reuben, putting an arm now around Ponter's massive shoulders, "and I'm not sure how he got here, but this man's name is Ponter, and—"

Reuben stopped. Singh looked at him. Reuben knew he could conclude with that; yes, the man's name was known. He didn't have to say anything more. He could stop now, and no one would think him crazy. But if he went on—

If he went on, all hell would break loose.

"Can you spell that?" called a reporter.

Reuben closed his eyes, summoning strength from within. "Only phonetically," he said, now looking at the journalist. "P-O-N-T-E-R. But whichever of you jotted that down the fastest is, I'm sure, the first person ever to render that name in the English alphabet." He paused again, looked once more at Singh for encouragement, then pressed on. "This gentleman here, we are beginning to suspect, is not *Homo sapiens sapiens*. He may be—well, I think anthropologists are still arguing about what the proper designation for this kind of hominid is, aren't they? He seems to be what they call either *Homo neanderthalensis* or *Homo sapiens neanderthalensis*—at any rate, he's apparently a Neanderthal."

"What?" said one of the reporters.

Another just snorted derisively.

And a third—the mining reporter from the Sudbury *Star*—pursed his lips. Reuben knew that reporter had a bachelor's in geology; doubtless he'd taken a paleo course or two as part of his studies. "What makes you say that?" he asked skeptically.

"I've seen x-rays of his skull. Dr. Singh here was quite sure of the identification."

"What does a Neanderthal have to do with the destruction of SNO?" asked a reporter.

Reuben shrugged, acknowledging that that was a very good question. "We don't know."

"This has got to be a hoax," said the mining reporter. "It's *got* to be."

"If it is, I've been hoodwinked, and so

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has Dr. Singh."

"Dr. Singh," called a reporter, "is this—this person here—is he a caveman?"

"I'm sorry," said Singh, "but I cannot discuss a patient except with other involved physicians."

Reuben looked at Singh, agog. "Dr. Singh, please . . ."

"No," said Singh. "There are rules . . ."

Reuben looked down for a moment, thinking. He then turned to Ponter with pleading eyes. "It's up to you," he said.

Ponter surely didn't understand the words, but apparently he grasped the significance of the situation. Indeed, it occurred to Reuben that Ponter might have a good shot at making a run for it, if he were so inclined; although not particularly tall, he was burlier by far than either of the cops. But Ponter's eyes soon swung in the direction of Singh—and, as Reuben followed the Neanderthal's line of sight, he realized that Ponter was actually looking at the manila envelope Singh was clutching tightly.

Ponter strode over to Singh. Reuben saw one of the cops put his hand on his holster; he evidently assumed Ponter was going to attack the doctor. But Ponter stopped short, right in front of Singh, and held out a beefy hand, palm up, in a gesture that transcended cultures.

Singh seemed to hesitate for a second, then he relinquished the envelope. There was no illuminated viewing plate in here, and it was now well after dark. But there was a large window, with light from a lamp in the parking lot streaming in. Ponter moved to the window; he perhaps knew that the cops would have tried to restrain him if he'd gone instead for the glass doors leading outside. He then held one of the x-rays, the side view, up against the glass so that everyone could see it. Camcorders were instantly trained on it, and more still pictures were taken. Ponter then gestured for Singh to come over. The Sikh did so, and Reuben followed. Ponter tapped on the x-ray, then pointed at Singh. He repeated the sequence two or three times, and then opened and closed his left hand with fingers held straight, the—apparently universal—gesture for "talk."

Dr. Singh cleared his throat, looked around the lobby surveying the faces, then shrugged a little. "It, ah, it seems I have my patient's permission to discuss his x-rays." He pulled a pen out of his lab coat's breast pocket and used it as a pointer. "Do you all see this rounded protrusion at the back of the skull? Paleoanthropologists call that the occipital bun . . ."

Chapter 8

Mary Vaughan had slowly driven the ten kilometers to her apartment in Richmond Hill. She lived on Observatory Lane, near the David Dunlap Observatory, once—briefly, and a long time ago—home of the world's largest optical telescope, now reduced to little more than a teaching facility because of the lights from Toronto.

Mary had bought the condominium here in part because of its security. As she drove up the driveway, the guard in the gatehouse waved at her, although Mary couldn't meet his—or anyone's—eyes yet. She drove along, past the manicured lawn and large pines, around back, and down into the underground garage. Her parking spot was a long walk from the elevators, but she'd never felt unsafe doing it, no matter how late it was. Cameras hung from the ceiling, between the sewer and water pipes and the sprinklers poking down like the snouts of star-nosed moles. She was watched every step of the way to the elevators, although tonight—this one hellish night—she wished that no one could see her.

Was she betraying anything by how she walked? By the quickness of her step? By her bowed head, by the way she clutched the front of her jacket as though the buttons were somehow failing to provide enough security, enough

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closure?

Closure. No, there was surely no way she could ever have that.

She entered the P2 elevator lobby, pushing first one door then the other open in front of her. She then pressed the single call button—there was nowhere to go from here but up—and waited for one of the three cars to come. Normally, when she waited, she looked at the various notices put up by management or other residents. But tonight Mary kept her eyes firmly on the floor, on the scuffed, stippled tiles. There were no floor-number indicators to watch above the closed doors, as there were two levels up in the main lobby, and although the "UP" button would go dark a few seconds before one of the doors would rumble open, she chose not to watch for that, either. Oh, she was eager to be home, but after one initial glance, she couldn't bring herself to look at the glowing upward-pointing arrow . . .

Finally, the farthest of the doors yawned. She entered and pushed the button for the fourteenth floor—really the thirteenth, of course, but that designation was considered unlucky. Above the panel of numbers was a glass frame that contained a laser-printed notice saying, "Have a Nice Day—From Your Board of Directors."

The elevator made its ascent. When it stopped, the door shuddered to one side, and Mary headed down the corridor—recently recarpeted by order of the same Board of Directors in a hideous cream-of-tomato-soup shade—and came to her apartment door. She fished in her purse for her keys, found them, pulled them out, and—

—and stared at them, tears welling in her eyes, vision blurring, her heart pounding again.

She had a small key chain, and on its end, a gift a dozen years ago from her ever-practical then-mother-in-law, was a yellow plastic rape whistle.

There had never been a chance to use it—not until it was too late. Oh, she could have blown it after the attack, but . . .

. . . but rape was a crime of violence, and she had survived it. A knife had been held to her throat, been pressed against her cheek, and yet she hadn't been cut, hadn't been disfigured. But if she'd sounded the alarm, he might have come back, might have killed her.

There was a gentle chime; another elevator had arrived. One of her neighbors would be in the corridor within a second. Mary fumbled the key into the lock, the whistle dangling, and quickly entered her dark apartment.

She hit the switch, the lights came on, and she turned around and closed the door, cranking over the lever that caused the deadbolt to clunk into place.

Mary removed her shoes and passed through the living room, with its peach-colored walls, noting, but not caring, that the red eye on the answering machine was winking at her. She entered her bedroom and took off her clothes—clothes that she knew she would throw out, clothes that she could never wear again, clothes that could never come clean no matter how many times they were washed. She then entered the *en suite* bathroom, but didn't turn on the light in there; she made do with the illumination spilling in from the Tiffany lamps on her night tables. She climbed into the shower and, in the semi-darkness, she scrubbed and scrubbed and scrubbed until her skin felt raw, and then she got out her heavy flannel pajamas—the ones she saved for the coldest winter nights, the ones that covered her most completely—and she put them on, and she crawled into bed, hugging herself and shivering and crying some more and finally, finally, finally, after hours of trying, falling into a fitful sleep punctuated by dreams of being chased and dreams of fighting and dreams of being cut with knives.

Reuben Montego had never met his

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ultimate boss, the president of Inco, and the doctor was actually surprised to find he had a listed number. With considerable trepidation, Reuben called him.

Reuben was proud of his employer. Inco had started, like so many Canadian companies, as a subsidiary of an American firm: in 1916, it had been created as the Canadian arm of the International Nickel Company, a New Jersey mining concern. But twelve years later, in 1928, the Canadian subsidiary became the parent company through an exchange of shares.

Inco's principal mining operations were in and around the meteor crater here in Sudbury where, 1.8 billion years ago, an asteroid between one and three kilometers wide had slammed into the ground at fifteen klicks per second.

Inco's fortunes rose and fell along with the worldwide demand for nickel; the company provided a third of the world's supply. But during it all, Inco really did strive to be a good corporate citizen. And when Herbert Chen of the University of California had proposed, in 1984, that the depth of Inco's Creighton Mine, its low natural radioactivity, and the availability of large amounts of heavy water stockpiled for use in Canada's CANDU reactors, made Sudbury the ideal location for the world's most advanced neutrino detector, Inco had enthusiastically agreed to make the site available for free, and to do the additional excavation for the ten-story-tall detector chamber, and the 1,200-meter drift leading to it, at cost.

And although the Sudbury Neutrino Observatory was a joint project of five Canadian universities, two American ones, Oxford, and America's Los Alamos, Lawrence Berkeley, and Brookhaven National Laboratories, any trespassing charges against this Neanderthal, this Ponter, would have to be laid by the site's owner. And that was Inco.

"Hello, sir," Reuben said, when the president answered the phone. "Please forgive me for disturbing you at home. This is Reuben Montego. I'm the site doc—"

"I know who you are," said the cultured, deep voice.

That flustered Reuben, but he pressed on. "Sir, I'd like you to call the RCMP and tell them that Inco is not going to press any charges against the man found inside the Sudbury Neutrino Observatory."

"I'm listening."

"I've managed to convince the hospital not to discharge the man. Massive heavy-water ingestion can be fatal, according to the Material Safety Data Sheet. It upsets the osmotic pressure across cell boundaries. Now, the man couldn't possibly have taken in enough to do real damage, but we're using that as a pretext to keep him from being discharged. Otherwise, he'd be in the slammer right now."

"'The slammer,'" repeated the president, sounding amused.

Reuben felt even more discombobulated. "Anyway, like I said, I don't think he belongs in prison."

"Tell me why," said the voice.

And Reuben did just that.

The president of Inco was a decisive man. "I'll make the call," he said.

Ponter was lying on a—well, it was a bed, he supposed, but it wasn't recessed to be flush with the floor; instead it was raised up by a harsh-looking metal frame. And the pillow was an amorphous bag stuffed with—he wasn't sure what, but it certainly wasn't dried pine nuts, like his pillow back home.

The bald man—Ponter had now seen that there was a stubble against his dark scalp, so the baldness must be an affectation, not a congenital condition—had left the room. Ponter had interlaced his fingers behind his own head, giving some firmer support for his skull. It wasn't rude to Hak. His Companion's scanners perceived everything within a couple of paces; it only needed its directional lens uncovered when look-

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ing at an object outside its scanning range.

"It's clearly nighttime," said Ponter, into the air.

"Yes," said Hak. Ponter could feel the cochlear implants vibrate slightly as his head pressed back against his arms.

"But it's not dark out. There's a window in this room, but they seem to have flooded the outdoors with artificial light."

"I wonder why?" said Hak.

Ponter got up—so strange to dangle one's feet over the side of the bed in order to rise—and hurried to the window. It was too bright to see stars, but—

"It's there," said Ponter, facing his wrist out through the glass so Hak could see.

"That's Earth's moon, all right," said Hak. "And its phase—a waning crescent—is exactly right for today's date of 148/118/24."

Ponter shook his head and moved back to the strange, elevated bed. He sat on the edge of it; it was uncomfortable to do so, what with no back support. He then touched the side of his head, which had been bandaged by the man with the wrapped head; Ponter wondered if that man's bandages were because of a massive head wound of his own. "I hurt my head," Ponter said, into the air.

"Yes," replied Hak, "but you saw the deepviews they took of you; there was no serious damage done."

"But I almost drowned, too."

"That's certainly true."

"So . . . so maybe my brain was injured. Anoxia, and all that . . ."

"You think you're hallucinating?" asked Hak.

"Well," said Ponter, lifting his right arm, and gesturing at the bizarre room around him, "how else to explain all this?"

Hak was silent for a moment. "If you *are* hallucinating," the Companion said, "then my telling you that you are not could just be part of that hallucination. So there's really no point in me trying to disabuse you of that notion, is there?"

Ponter lay back down on the bed and stared up at the ceiling, which was devoid of timepieces and artwork.

"You really should try to get some sleep," said Hak. "Maybe things will make more sense in the morning."

Ponter nodded slightly. "White noise," he said. Hak complied, playing a soft, soothing hiss through the cochlear implants, but still it seemed to Ponter to be a long time before he fell asleep.

Chapter 9

DAY TWO
Saturday, August 3
148/118/25

Adikor Huld couldn't take being inside the house. Everything there reminded him of poor, vanished Ponter. Ponter's favorite chair, his datapad, the sculptures Ponter had selected—everything. And so he'd gone out back, to sit on the deck, to stare sadly at the countryside. Pabo came out and looked at Adikor for a time; Pabo had been Ponter's dog—he'd had her long before Adikor and Ponter had begun living together. Adikor would keep her—if only so the house would not be so lonely. Pabo went back inside. She'd be going to the front door, Adikor knew, looking out there to see if Ponter were returning. She'd trekked back and forth, looking through both doors, ever since Adikor had come home yesterday. Adikor had never returned from work without Ponter before; poor Pabo was baffled and clearly very sad.

Adikor was hugely sad, too. He'd been crying off and on for most of the morning. Not blubbering, not wailing—just crying, sometimes even unaware of it himself until a fat drop splashed down onto his arm or hand.

Rescue teams had searched exhaustively in the mine, but they'd found no sign of Ponter. They'd used portable

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equipment to scan for his Companion, but had been unable to detect its transmissions. Humans and dogs had passed through drift after drift, trying to catch the odor of a man who might be unconscious, lying hidden from view.

But there was nothing. Ponter had vanished utterly and completely, without a trace.

Adikor shifted his weight in his chair. The chair was made of pine boards with a back that flared out and arms that had wide, flat rests on which a drinking tube could easily be balanced. There was no doubt the chair was useful. Its maker—Adikor forgot the woman's name, but it was branded on the back of the chair—doubtless felt she contributed sufficiently to society. People needed furniture; Adikor had a table and two cabinets made by the same carpenter.

But what would Adikor's contribution be, now that Ponter was gone? Ponter had been the brilliant one of the pair; Adikor recognized that and had accepted it. But how would he contribute now, without Ponter, dear, dear Ponter?

The quantum-computing work was dead, as far as Adikor could see. With Ponter gone, it couldn't go on. Others—there was that female group across the ocean in Evsoy, and another male one on the west coast of this continent—would continue work along related lines. He wished them luck, he supposed, but although he would read their reports with interest, part of him would always regret that it was not Ponter and him making the breakthroughs.

Aspens and birches formed a shady canopy around the deck, and white trilliums bloomed at the trees' mossy bases. A chipmunk scurried by, and Adikor could hear a woodpecker tapping away at a trunk. He breathed deeply, inhaling pollens and the smells of mulch and soil.

There was a sound of something moving; occasionally, a large animal would wander this close to a home during the day, and—

Suddenly, Pabo came tearing out of the back door. She'd detected the arrival, too. Adikor flared his nostrils. It was a person—a man—coming.

Could it be—?

Pabo let out a plaintive whimper. The man came into view.

Not Ponter. Of course not.

Adikor's heart hurt. Pabo made her way back into the house, back to the front, to continue her vigil.

"Healthy day," said Adikor to the man now coming up on the deck. It was no one he'd ever seen before: a stocky fellow, with reddish hair. He wore a loose-fitting dark-blue shirt and a gray pant.

"Is your name Adikor Huld, and do you reside here in Saldak Rim?"

"Yes to the former," said Adikor, "and obviously to the latter."

The man held up his left arm, with the inside of his wrist facing Adikor; he clearly wanted to transfer something to Adikor's Companion.

Adikor nodded and pulled a control bud on his Companion. He watched the little screen on his unit flash as it received data. He expected it to be a letter of introduction: this perhaps was a relative visiting the area, or maybe a tradesperson looking for work, transferring his credentials. Adikor could erase the information easily enough if it were of no interest.

"Adikor Huld," said the man, "it is my duty to inform you that Daklar Bolbay, acting as *tabant* of the minor children Jasmel Ket and Megameg Bek, is accusing you of the murder of their father, Ponter Boddit."

"What?" said Adikor, looking up. "You're joking."

"No, I'm not."

"But Daklar is—was—Klast's womanmate. She's known me for ages."

"Nonetheless," said the man. "Please show me your wrist so that I can confirm that the appropriate documents have been transferred."

Adikor, stunned, did just that. The man merely glanced at the display—it

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said "Bolbay charging Huld, transfer complete"—then he looked back at Adikor. "There will be a *dooslarm basadlarm*"—an old phrase that literally meant "asking small before asking large"—"to determine if you should face a full tribunal for this crime."

"There's been no crime!" said Adikor, fury growing within him. "Ponter is missing. He may be dead—I grant you that—but if so, it was an accident."

The man ignored him. "You are free to choose any one person to speak on your behalf. The *dooslarm basadlarm* has been scheduled for tomorrow morning."

"Tomorrow!" Adikor felt his fist clenching. "That's ridiculous!"

"Justice postponed is no justice at all," said the man as he walked away.

Chapter 10

Mary needed coffee. She rolled out of her single bed, made her way to the kitchen, and set the coffeemaker to its task. She then stepped into the living room and pushed the play button on her answering machine, an old, reliable silver-and-black Panasonic that made loud clunkings when it started and stopped rewinding its tape.

"Four new messages," announced the cold, emotionless male voice, and then they began to play.

"Howdy, Sis, it's Christine. I just *have* to tell you about this new guy I'm seeing—I met him at work. Yeah, I know, I know, you always say never get involved with anyone at the office, but, really, he is *so* cute, and so nice, and so funny. Honest to God, Sis, he's a real find!"

A real find, thought Mary. Good grief, another real find.

The mechanical voice again: "Friday, 9:04 P.M." That was just after six Sacramento time; Christine must have called as soon as she'd gotten home from the office.

"Hey, Mary, it's Rose. Haven't seen you for ages. Let's do lunch, eh? Don't they have a Blueberry Hill up at York? I'll come up there, and we'll go—they closed the one near me. Anyway, I guess you're out right now—hope you're having a great time, whatever you're doing. Give me a call."

The machine's voice: "Friday, 9:33 P.M."

Christ, thought Mary. Good Christ. That would have been precisely when . . . when . . .

She closed her eyes.

And then the next message played: "Professor Vaughan?" said a voice with a Jamaican accent. "Is this the home of Professor Mary Vaughan, the geneticist? I'm sorry if it isn't—and I hate to be calling so late; I tried the York campus, on the off-chance that you were still there, but only got your voice mail. I had directory assistance give me the numbers for every M. Vaughan in Richmond Hill—that's where an article I found about you on the web said you live." Mary's outgoing message said only, "This is Mary," but the caller had presumably been buoyed by that. "Anyway—God, I hope I don't get cut off here—look, my name is Reuben Montego, and I'm an M.D.; the camp doctor up at Inco's Creighton Mine in Sudbury. I don't know if you've seen the news reports on this yet, but we've found a . . ." He paused, and Mary wondered why; he'd been burbling to this point. "Well, look, if you haven't seen the reports, let's just say we've found what we believe to be a Neanderthal specimen in, ah, remarkable condition."

Mary shook her head. There were no Neanderthal fossils from anywhere in North America; the guy must have some old Native Canadian material . . .

"Anyway, I did a web search on 'Neanderthal' and 'DNA,' and your name kept coming up. Can you—"

Beep. The guy had indeed exceeded the maximum message length.

"Friday, 10:20 P.M.," reported the robotic voice.

"Damn, I hate these things," said Dr. Montego, coming on again. "Look, what

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I was saying was, we'd really like you to authenticate what we've got here. Give me a call—any time, day or night, on my cell phone at . . ."

She didn't have time for this. Not today, not anytime soon. Still, Neanderthals weren't her only interest; if it was a well-preserved ancient Native bone, that would be intriguing, too—but the preservation would have to be remarkable indeed for the DNA to have not deteriorated, and—

Sudbury. That was in Northern Ontario. Could they have—?

That would be fabulous. Another ice man, frozen solid, maybe found buried deep in a mine.

But, sweet Jesus, she didn't want to think about that right now; she didn't want to think about anything.

Mary went back into the kitchen and filled a mug with the now-ready coffee, which she poured a little chocolate milk into from a half-liter carton—she didn't know anyone else who did that, and she had given up trying to get it in restaurants. She then returned to the living room and put on the TV, a 14-inch set that normally didn't get much use; Mary preferred to curl up with a John Grisham novel, or, occasionally, a Harlequin romance, when she was home in the evenings.

She used the remote to select CablePulse 24, a 24-hour news channel that devoted only part of its screen to the newscast; the right-hand side showed weather and financial information, and the bottom flashed headlines from *The National Post*. Mary wanted to see what today's high would be, and if it was going to finally rain, taking some of the awful humidity out of the air, and—

"—the destruction of the Sudbury Neutrino Observatory yesterday," said the Skunk Woman; Mary could never remember her name, but she had an incongruous white streak in her otherwise dark hair. "Few details are yet known, but the facility, buried more than two kilometers underground, apparently suffered a major accident at about 3:30 P.M. No one was hurt, but the seventy-three-million-dollar lab is currently shut down. The detector, which made headlines around the world last year by solving the so-called Solar Neutrino Problem, probes the mysteries of the universe. It opened with great fanfare in 1998, with a visit by renowned physicist Stephen Hawking." File footage of Hawking in his wheelchair going down a mineshaft elevator ran behind the Skunk Woman's words.

"And speaking of mysteries, there are claims from a hospital in Sudbury that a *living* Neanderthal was found inside the mine. We have a report from Don Wright. Don?"

Mary watched, absolutely stunned, as a Native Canadian journalist gave a brief report. The guy they were showing on screen did indeed have browridges, and—

—God, the skull, glimpsed briefly in an x-ray that someone was holding up against a window . . .

It *did* look Neanderthal, but . . .

But how could that be? How could that possibly be? For Pete's sake, the guy was clearly not a wild man, and he had a funky hair cut. Mary watched CablePulse 24 often enough; she knew they weren't above occasionally airing stories that amounted to little more than thinly disguised promos for current movies, but . . .

But Mary subscribed to the hominid listserv; there was enough idle chatter on it that there was no way she could have failed to have heard if a movie about Neanderthals was going to be made here in Ontario.

Sudbury . . . She'd never been to Sudbury, and—

And, Christ, yes, it would do her some good to just get the hell away from here for a while. She pushed the backward-review button on her phone's caller-ID display; a number with a 705 area code was the first to appear. She hit

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the dial button, and settled back into her Morticia seat, a high-backed wicker chair that was her favorite. After three rings, the voice she'd already heard answered. "Montego."

"Dr. Montego, this is Mary Vaughan."

"Professor Vaughan! Thank you for calling back. We've got . . ."

"Dr. Montego, look—you have no idea how . . . how . . . *swamped* I am right now. If this is a joke, or—"

"It's no joke, Professor, but we don't want to take Ponter anywhere yet. Can you come up here to Sudbury?"

"You're absolutely sure you've got something real?"

"I don't know; that's what we want you to tell us. Look, we're also trying to reach Norman Thierry at UCLA, but it's not even 8:00 A.M. there yet, and—"

Jesus, she didn't want Thierry to get this; if this was for real—although, God, how could it be?—it would be absolutely huge.

"Why do you need me to come up there?" asked Mary.

"I want you to take the DNA specimens directly; I want there to be no question about their authenticity or where they came from."

"It would take—God, I don't know, maybe four hours to drive to Sudbury from here."

"Don't worry about that," said Montego. "We've had a corporate jet standing by at Pearson since last night, in case you did call. Grab a cab, get over to the airport, and we can have you up here before noon. Don't worry; Inco will reimburse all your expenses."

Mary looked around her apartment, with its white bookcases and wicker furniture, her collection of Royal Doulton figurines, the framed Renoir prints. She could drop by York University to pick up the appropriate primers, but . . .

No. No, she didn't want to go back there. Not yet, not today—maybe not until September, when she had to start teaching again.

But she *would* need the primers. And it was day now, and she could park over in Lot DD, approaching the Farquharson Building from a completely different direction, not going anywhere near where . . .

Where . . .

She closed her eyes. "I'll have to go by York to get some things, but . . . yes, all right, I'll do it."

Chapter 11

It was twenty-four days until Two would next become One, that fabulous four-day holiday Adikor Huld so looked forward to each month. But, despite propriety, he certainly couldn't wait until then to talk with the person he hoped would speak on his behalf at the *dooslarm basadlarm*. He could have called her with voice communication, but so much was lost when only words, without gestures or pheromones, were exchanged. No, this was going to be very delicate; it clearly merited a trip into the Center.

Adikor used his Companion to call for a car and driver. The community had over three thousand cars; he shouldn't have to wait long for one to come and get him.

His Companion spoke to him. "You know it's Last Five, don't you?"

Gristle! He'd forgotten that. The effect would be in full swing. He'd only twice before gone into the Center during Last Five; he'd known men who had never done it, and he had teased them, saying he'd barely gotten out with his life.

Still, it was probably a wise precaution to slip into the pool again before going in, to cut down on his own pheromones. He went and did precisely that.

Once done, he dried off with a cord, then dressed in a dark brown shirt and a light-brown pant. No sooner had he finished than the public car settled to the ground outside the house. Pabo, still looking for Ponter, ran out to see who had arrived. Adikor walked out more

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slowly.

The car was the latest version, mostly transparent, with two ground-effect motors underneath and chairs at each of its corners, one of which was occupied by the driver. Adikor got in, folding himself against the heavily padded saddle-seat next to the driver.

"You're going into the Center?" said the driver, a 143 with a bald stripe running back over his head, where his part had widened.

"Yes."

"You know it's Last Five?"

"I do."

The driver chuckled. "Well, I won't be waiting around for you."

"I know," said Adikor. "Let's go."

The driver nodded and operated the controls. The car had good sound-deadening; Adikor could barely hear the fans. He settled in for the ride. They passed a couple of other cars, both of which had male passengers. Adikor thought that drivers probably felt quite useful; he himself had never operated a public car, but maybe *that* was a job he'd enjoy . . .

"What's your contribution?" asked the driver in an easy tone, making conversation.

Adikor continued to look out the car's walls at the scenery going by. "I'm a physicist."

"Here?" said the driver, sounding incredulous.

"We have a facility down one of the mineshafts."

"Oh, yeah," replied the driver. "I've heard about that. Fancy computers, right?"

A goose was flying by overhead, its white cheeks stark against its black neck and head. Adikor tracked it with his eyes. "Right."

"How's that going?"

Being accused of a crime changed your perspective on everything, Adikor realized. Under normal circumstances, he might have just said "Fine," rather than go into the whole sorry mess. But even the driver might be called for questioning at some point: "Yes, Adjudicator, I drove Scholar Huld, and when I asked him how things were going at his computing facility, he said 'fine.' Ponter Boddit was dead, but he didn't show any remorse at all."

Adikor took a deep breath, then measured his words carefully. "There was an accident yesterday. My partner was killed."

"Oh," said the driver. "I'm sorry to hear that."

The landscape was barren at this point: ancient granite outcrops and low brush. "Me, too," Adikor said.

They continued on in silence. There was no way he could be found guilty of murder; surely the adjudicator would rule that if there was no body, there was no proof that Ponter was dead, let alone that he had fallen victim to foul play.

But if—

If he were convicted of murder, then—

Then what? Certainly he'd be stripped of his property, and all of it would be given to Ponter's woman-mate and children, but . . . but, no, no, Klast had been dead for twenty months now.

But beyond taking his property, what else?

Surely . . . surely not *that*.

And yet, for murder, what other penalty could they prescribe? It seemed inhumane, but it had been invoked whenever necessary since the first generation.

Surely, though, he was worrying for nothing. Daklar Bolbay was obviously inconsolable over the loss of Ponter, who had been her woman-mate's man-mate—Klast's female partner, whom she lived with, was Daklar; Klast's male partner, whom she spent time with when Two became One, was Ponter. Doubtless after a day or two, Bolbay would come to her senses, and the accusation would be withdrawn with an apology tendered.

And Adikor would graciously accept the apology; what else could he do?

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But if she *didn't* drop the charge? If Adikor had to proceed with this nonsense all the way to a full tribunal? What then? Why, he'd have to—

The driver broke Adikor's contemplation by speaking again. "We're almost to the Center. Do you have an exact address?"

"North side, Milbon square."

Adikor could see the back of the driver's head move up and down as he nodded acknowledgment.

They were indeed approaching the Center: the open lands were giving way to stands of aspen and birch, and clusters of buildings made of cultured trees and gray brick. It was almost noon, and the clouds of earlier in the day had vanished.

As they continued in, Adikor saw first one, and then another, and then several more, walking along: the most beautiful creatures in all the world.

One of a pair of them caught sight of the public car, and pointed at Adikor. It wasn't all that unusual for a man to be coming into the Center at sometime other than the four days during which Two became One, but it *was* noteworthy during Last Five, the final days of the month.

Adikor tried to ignore the stares of the women as the driver took him in deeper.

No, he thought. No, they couldn't find him guilty. There was no body!

And yet, if they did . . .

Adikor squirmed in his seat as the car flew on. He could feel his scrotum contracting, as if its contents wanted to climb into his torso, out of harm's way.

Chapter 12

Reuben Montego was delighted that Mary Vaughan was on her way up from Toronto. Part of him was hoping that she could prove genetically that Ponter *wasn't* a Neanderthal, that she could show he was just a plain old garden-variety human being. That would restore some rationality to the situation; after a fitful night's sleep, Reuben realized that it really was easier to swallow the idea that some nut had had himself altered to look like a Neanderthal, rather than that he actually *was* one. Perhaps Ponter was indeed a member of some weird cult, as Reuben had first thought. If he'd worn a series of tight helmets while growing up, each of which had their interiors sculpted to look like a Neanderthal head, his own skull could have grown into that shape. And at some point, he'd obviously had that submaxillary surgery to give his lower jaw the same prehistoric cast . . .

Yes, it *could* have happened that way, thought Reuben.

There was no point going directly to the Sudbury airport; it would still be a couple of hours before Professor Vaughan arrived. Reuben headed to St. Joseph's Health Centre to see how Ponter was doing.

The first thing he noticed when he entered the hospital room was the dark semicircles beneath Ponter's deep-set eyes. Reuben was delighted that he himself was not subject to such signs of fatigue. His parents, back in Kingston (Jamaica, that is, not Ontario—although he'd lived briefly for a time there, too) hadn't been able to tell when he'd stayed up half the night reading comic books.

Perhaps, thought Reuben, Dr. Singh should have prescribed a sedative for Ponter. Even if he really was a Neanderthal, almost certainly any that worked on regular humans would be effective on him, too. But, then again, if it had been his call to make, Reuben might have erred on the side of caution himself.

In any event, Ponter was now sitting up in bed, eating a late breakfast a nurse had just brought him. He had looked at the tray for a time after its arrival, as though something was missing. He'd finally wrapped his right hand in the white linen napkin, and was using that covered hand to eat with, picking up

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strips of bacon one at a time. He only used cutlery for the scrambled eggs, and for those he employed the spoon rather than the fork.

Ponter set the toast back down after sniffing it. He also disdained the contents of the little box of Kellogg's Corn Flakes, although he did seem to enjoy puzzling out the complex perforations to open it up into a self-contained bowl. After a tentative sip, he drained the small plastic cup of orange juice in a single gulp, but he seemed to want nothing to do with either the coffee or the 250-milliliter carton of partially skimmed milk.

Reuben went to the bathroom to get Ponter a cup of water—and he stopped dead in his tracks.

Ponter *was* from somewhere else. He had to be. Oh, it was common enough for a person to forget to flush the toilet, but . . .

But Ponter not only hadn't flushed—he had wiped himself with the long, thin "Sanitized for Your Protection" loop, instead of with the toilet paper. No one from anywhere in the developed world could possibly make that mistake. And Ponter *was* indeed from a technological culture; there was that intriguing implant on the inside of his left wrist.

Well, thought Reuben, the best way to find out about this man was by talking with him. He clearly didn't—or wouldn't—speak English, but, as Reuben's old grandmother used to say, there be nine and sixty ways to skin a cat.

"Ponter," said Reuben, using the one word he'd picked up the previous night.

The man was silent for a moment too long, and he tilted his head slightly. Then he nodded, as if acknowledging someone other than Reuben. "Reuben," said the man.

Reuben smiled. "That's right. My name is Reuben." He spoke slowly. "And your name is Ponter."

"Ponter, *ka*," said Ponter.

Reuben pointed at the implant on Ponter's left wrist. "What's that?" he said.

Ponter lifted his arm. *"Pasalab,"* he said. Then he repeated it slowly, syllable by syllable, presumably understanding that a language lesson had begun: *"Pas-a-lab."*

And with that, Reuben realized he'd made a mistake; there was no corresponding English word he could now supply. Oh, perhaps "implant," but that seemed such a generic term. He decided to try something different. He held up one finger. "One," he said.

"Kolb," said Ponter.

He made a peace sign. "Two."

"Dak," said Ponter.

Scout's honor. "Three."

"Narb."

Four fingers. "Four."

"Dost."

A full hand, digits splayed. "Five."

"Alm."

Reuben continued, adding a finger at a time from his left hand until he had heard numerals from one to ten. He then tried the numbers out of sequence, to see if Ponter would always give the same word in response, or was just making it up as he went along. As far as Reuben could tell—he was having trouble keeping track of these strange words himself—Ponter never slipped up. It wasn't just a stunt; it seemed to be a real language.

Reuben next started indicating parts of his own body. He pointed an index finger at his shaved head. "Head," he said.

Ponter pointed at his own head. *"Kadun,"* he said.

Next, Reuben indicated his left eye. "Eye."

And then, Ponter did something astonishing. He lifted his right hand, palm out, as if asking Reuben to hold on for a minute, and then he began talking rapidly in his own language, with his head slightly lowered and cocked, as if speaking to somebody over an invisible

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telephone.

"This is pathetic!" said Hak, through Ponter's cochlear implants.

"Yeah?" replied Ponter. "We're not all like you, you know; we can't just download information."

"More's the pity," said Hak, "but, really, Ponter, if you'd been paying attention to what they'd been saying to each other and to you since we got here, you'd already have picked up a lot more of their language than a simple list of nouns. I have cataloged with high confidence one hundred and sixteen words in their language, and with reasonable confidence guessed at another two hundred and forty, based on the context in which they have been used."

"Well," said Ponter, somewhat miffed, "if you think you can do a better job than me . . ."

"With all due respect, a chimpanzee could do a better job than you at learning language."

"Fine!" said Ponter. He reached down and pulled out the control bud on his Companion that turned on the external speaker. "You do it!"

"My pleasure," said Hak, through the cochlear implants, then, switching to the speaker—

"Hello," said a female voice. Reuben's heart jumped. "Yoo-hoo! Over here."

Reuben looked down. The voice was coming from the strange implant on Ponter's left wrist. "Talk to the hand," the implant said.

"Umm," said Reuben. And then, "Hello."

"Hello, Reuben," replied the female voice. "My name is Hak."

"Hak," repeated Reuben, shaking his head slightly. "Where are you?"

"I am here."

"No, I mean *where* are you? I get that that thingamajig is some kind of cell phone—say, you know, you're not supposed to use those in hospitals; they can interfere with monitoring equipment. Could we call you back—"

Bleep!

Reuben stopped talking. The bleep had come from the implant.

"Language learning," said Hak. "Follow."

"Learning? But . . ."

"Follow," repeated Hak.

"Um, yes, all right. Okay."

Suddenly, Ponter nodded, as if he'd heard a request that Reuben hadn't. He pointed at the door to the room.

"That?" said Reuben. "Oh, that's a door."

"Too much words," said Hak.

Reuben nodded. "Door," he said. "Door."

Ponter got up out of the bed and walked toward the door. He put his large hand on the handle, and pulled the door open.

"Um," said Reuben. Then: "Oh! Open. Open."

Ponter closed the door.

"Close."

Ponter then swung the door repeatedly open and closed.

Reuben frowned, then, getting it: "Opening. You're opening the door. Or closing it. Opening. Closing. Opening. Closing."

Ponter walked over to the window. He indicated it with a sweep of both hands.

"Window," said Reuben.

He tapped on the glass.

"Glass," Reuben supplied.

The female voice again, as Ponter lifted the window up in its frame, exposing the screen: "I am opening the window."

"Yes!" said Reuben. "Opening the window! Yes."

Ponter pulled the window down. "I am closing the window," said the female voice.

"Yes!" said Reuben. "Yes, indeed!" ■

To be continued!

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Beyond the Periodic Table:
Artificial Atoms and Programmable Matter

Wil McCarthy

The concept of "programmable matter" may already be familiar to readers of the "Futures" column in *Nature*, or my Queendom of Sol stories, or my "Lab Notes" column at SciFi.com, where I've discussed the general principles and some possible future applications. However, this article—my first attempt to address the concept in a rigorous and overtly technical way—contains important thoughts and details which have not previously been discussed.

For the rest of you, who have no idea what I'm talking about or what programmable matter is, the easiest introduction is to list off some of the things it isn't. First off, it isn't any sort of virtual reality abstraction, but an actual, material substance. It isn't microtechnology or Micro Electro-Mechanical Systems (MEMS), and isn't nanotechnology, although it does require the fabrication of some middlin' fine nanostructures in order to work. It also isn't nuclear fission, fusion, or other transmutation reaction at the nuclear level.

What it *is*, is an array of electronic devices which employ quantum effects to change their apparent physical and chemical properties. Such change can occur over nanosecond timescales, with the input of only minuscule amounts of energy. Lead to gold? Sure, no problem. Sound like science fiction? Or alchemy? Read on and decide for yourself.

Nanotechnology's pioneer, K. Eric Drexler, proposed "smart materials" made of tiny, programmable nanomachines rather than normal, inert molecules. His proposal included future advances such as "paint" which could spread itself automatically, change color and texture on command, etc., and even "smart walls" in which the windows and doors could be moved around as easily as picture frames. Such a scenario is eminently reasonable, and will almost certainly occur someday.

But Drexler also proposed self-replicating nanomachines which would first produce millions of copies of themselves, then gang up to perform other miracles, and when people speak of nanotech and particularly of "Drexlerian" nanotech (other forms have been proposed, notably by the late Nobel laureate Richard Feynman), this is generally what they mean. Unfortunately, this is

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also where some of the greatest rubber-science abuses are occurring in science fiction today. In practice, the only known systems capable of this sort of massively parallel replication and atomic rearrangement are bacteria, molds, and plants, which perform their miracles very slowly. Nanotech may improve on these speeds somewhat, but short of forest-fire-type destruction, the flash and bang of instantaneous transformation are probably out of the question.

At the nanoscale, other problems crop up because the Bernoulli forces of fluid mechanics are dominant, swamping out gravity and thrust. Nanodevices will diffuse through the air like gas molecules, and be carried along in fluid flows (e.g., the bloodstream), all but helpless to control their motion, even assuming they somehow know where they are and where they want to go. Which is another problem, because interaction with the macroscopic world requires the construction of large effectors and sensory organs, and the infrastructure to support them, requiring still more time and energy and raw material. Really, by Clarke's law, Drexlerian nanotech is an insufficiently advanced technology: it doesn't look like magic at all.

With such difficulties in mind, in the early 1990s Dr. J. Storrs Hall of Rutgers University built on Drexler's concepts by proposing a "utility fog" of 12-armed, dust-sized silicon MEMS or micromachines. These "foglets" would be capable of joining hands in a variety of configurations, as well as extending and retracting their arms, and adjusting the optical characteristics of their faces. En masse, they create a programmable substance which can, on command, change its shape, density, and perhaps color.

As a modeling clay, holodeck-style puppet show, and airbag substitute, utility fog is beyond compare. And physically speaking, the technology doesn't seem too far out of reach; primitive MEMS, a thousand times larger than anything Drexler has proposed, can already be etched from silicon, including gears, pumps, electric motors, and even complex devices like microscopic steam engines. Today's MEMS suffer from a variety of strength and reliability problems (silicon is not the best material, just the one we happen to know best how to work with), but presumably these will be solved or worked around as the technology matures. Software challenges will be equally formidable; it isn't easy to get robots—especially microscopic ones—to perform complex tasks—especially in cooperation with thousands or millions of peers. But eventually we'll probably get there.

Of course, foglets can't reproduce or build anything else, and their texture and temperature and glassy composition would prevent them from masquerading as food or drink or living tissue, or really solid substances like stone or metal. Nor would they make good computers, or mirrors, or power cables, or floors. So utility fog may be neat stuff to have around, but it's not magic either.

In fact, by the time they find their way into the real world, both nanotech and microtech may wind up looking less magical than even a humble television screen, which after all can change its appearance instantly and completely. Fortunately, there may be a truly programmable substance in our future which is capable of changing its apparent physical and chemical properties as easily as a TV screen changes color.

How? Well, silicon does offer additional possibilities in its role as a semiconductor. Most materials are either conductors, which permit the free flow of electrons, or insulators, which resist it. Semiconductors are insulators which are capable of conducting electrons within a certain narrow energy band—a useful trick which makes integrated circuits and other electronics possible.

The Joy of Semiconductors

Of course, silicon's electrical properties are fixed by the laws of physics, but

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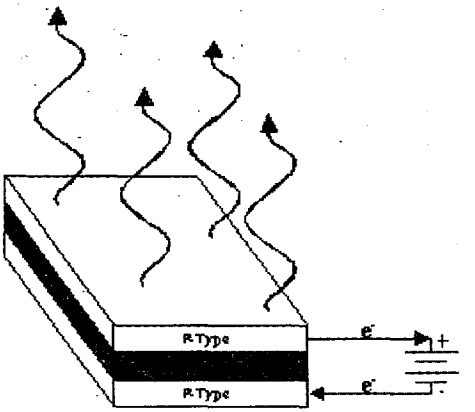

Figure 1: A quantum well produces photons when a voltage is applied

in a process known as "doping," very small and very precise amounts of another material can be scattered throughout the silicon's crystal lattice. Often, this doping is controlled almost to the level of individual atoms, and typically about one dopant atom is added per million atoms of substrate. This tiny impurity can wreak large changes in the silicon's behavior so that, for example, room-temperature electrons have a good chance of jumping up into the conduction band when a voltage is applied.

Silicon doped with electron-donor atoms such as phosphorus becomes an "N" or negative-type semiconductor, which contains one excess electron for every atom of dopant. These excess electrons have nowhere to bind, so they flow easily through the material, just as the more numerous excess electrons do inside a conductive metal. So "N"-type silicon is not so much a semiconductor as a genuine conductor, for very small and very precise current levels.

Doping with electron borrowers like aluminum produces a "P" or positive material, which conducts "holes," or spaces where an electron isn't. It seems counterintuitive, but electron holes can be manipulated and moved around as though they were positively charged particles. The analogy is that little puzzle where you slide the squares around, to unscramble a picture or a sequence of numbers—you rearrange the puzzle by moving the hole where you want it. Anyway, with "P"-type silicon you get one extra hole per atom of dopant, meaning that a small, precise number of excess electrons can be absorbed by the material. In other words, the flow of those electrons is sharply inhibited.

This may sound rather abstract, but it isn't; a "P" layer which is adjacent to an "N" layer creates a structure known as a P-N junction, which is a kind of electrical valve or gate that permits electrons to flow easily in one direction but not the other. This effect is critical in electronic components such as diodes, light-emitting diodes, and transistors. In fact, the latter half of the twentieth century was built almost entirely on P-N junctions; without them, we would not have the compact computers and communication devices which made all the other advances possible.

And in the years since 1989, another application for P-N junctions has been discovered which may, in the end, prove even more revolutionary. When an N

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layer is sandwiched between two Ps, a kind of "trap" is created which attracts electrons into the middle layer and doesn't let them out. This is a useful trait all by itself, and leads to a type of device called a P-N-P transistor, with opposite function than the usual N-P-N type. And if the middle N layer is thin enough, you can make still a different type: the resonant tunneling transistor. But if the N layer is *really* thin—about 10 nanometers or 0.000001 millimeters or 50 atoms high—then something weird starts to happen: the size of the trap approaches the de Broglie wavelength of a typical room-temperature electron.

Result? Along the vertical axis of the trap, the excess electrons can no longer move and propagate in the Newtonian way. Their positions and velocities take on an uncertain, probabilistic nature. They become waves, rather than particles.

Such devices, known as quantum wells (see Fig. 1), are easy and cheap to produce, and have the interesting property of producing photons of very precise wavelength, which means they can make laser beams, sometimes even without the need for a resonating chamber. Quantum wells find practical use in computers, fiber-optic networks, and those cute little $7 laser pointers you can buy for your keychain. Actually, as it happens, I'm oversimplifying slightly. For various reasons, quantum wells are not made of silicon, but of gallium arsenide (GaAs) and aluminum-gallium arsenide (AlGaAs), or similar materials from the same columns of the periodic table. This is partly because these materials allow electrons to accelerate and decelerate more easily, but mainly because they make for cleaner P-N junctions in which the transition from P layer to N layer is only a few atoms thick. In principle, you *could* have a silicon-based quantum well—under some circumstances it might even be desirable—but it would be harder to produce, and couldn't switch on and off as rapidly, which would limit its usefulness as a laser beam generator.

But the really exciting application for quantum wells has nothing to do with lasers. See, a quantum well confines electrons in a two-dimensional layer, like the meat inside a sandwich. But if the meat and the top bread layer are sliced away on two sides, leaving a narrow stripe of P-N sandwich on top of a sheet of P bread, the electrons take on wave-like behavior along an additional axis. This structure is called a "quantum wire," (Fig. 2) and is used to produce very intense laser beams which can be switched on and off much more rapidly than quantum well lasers can—up to 10 gigahertz, or 10 billion times per second. Quantum wires can also be used as precision waveguides, and of course as actual wires.

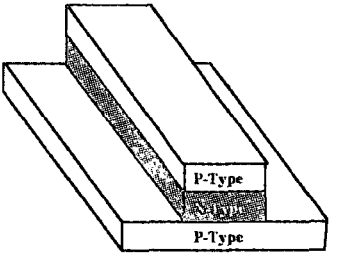

Figure 2: A quantum wire

But quantum wires too are of little interest to us here, except as a stepping stone. They lead us to a final step: etching away the sides of the stripe to leave a tiny square of meat and bread atop the lower slice, to produce a "quantum dot" (Fig. 3) which confines the electrons in all three dimensions. Unable to flow, unable to move as particles or even hold a well-defined position, the trapped electrons must instead behave as de Broglie standing waves, or probability density functions, or strangely shaped clouds of diffuse electric charge. Strangely shaped,

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because even as waves the negatively charged electrons will repel each other, and attempt to get as far apart as their energies and geometries permit.

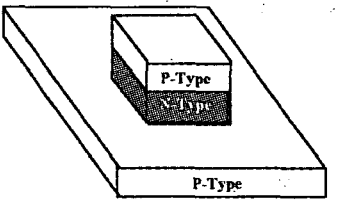

Figure 3: A quantum dot

If this sounds familiar, it's because there's another, more familiar place where electrons behave this way: in atoms. Electrons which are part of an atom will arrange themselves into "orbitals" which constrain and define their positions around the positively charged nucleus (Fig. 4). These orbitals, and the electrons which partially or completely fill them, are what determine the chemical properties of an atom, i.e., what other sorts of atoms it can bind to, and how strongly.

This point bears repeating: the electrons trapped in a quantum dot will arrange themselves just as though they were part of an atom, even though there's no atomic nucleus for them to surround. Which atom they resemble depends on the number of excess electrons trapped inside. What's more, the electrons in two adjacent quantum dots will interact just as they would in two real atoms placed at the equivalent distance, meaning the two dots can share electrons between them, meaning they can form chemical bonds. Not virtual or simulated bonds, but real ones—Daniel van der Weide of the University of Delaware and Werner Wegscheider of Munich University have demonstrated that the back-and-forth motion of electrons between bonded quantum dots is strikingly similar to the motion between atoms in a natural molecule.

Amazing, right? If you're not amazed, go back and read the last four paragraphs again. I'll wait.

Designer Atoms

Ready? Now we'll take it a step further: quantum dots needn't be formed by etching blocks out of a quantum well. Instead, the electrons can be confined electrostatically, by rings or squares of negatively charged material sitting on top of the upper "P" layer of the well, or better yet by electrodes whose voltage can be varied on demand, like a miniature electric fence or corral. In fact, this is the preferred method, since it permits

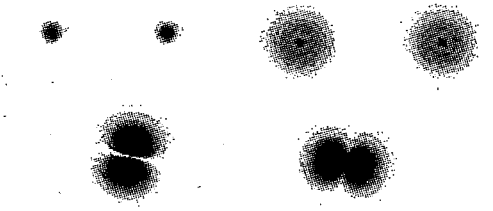

Figure 4: Electron orbitals of the carbon atom
(courtesy of David Manthey and *Orbital Viewer*)

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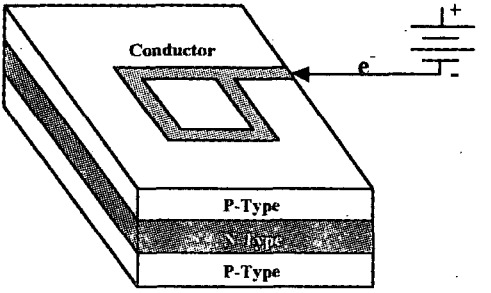

Figure 5: Artificial atom – one voltage source

the dots' characteristics to be adjusted without any physical modification of the underlying material. We can pump electrons in and out simply by varying the voltage on the fence.

This type of nanostructure is called an "artificial atom," or "designer atom," because it can be adjusted to resemble any atom on the periodic table (Fig. 5). It's not a science-fictional device, but a routine piece of experimental hardware, in daily use in laboratories throughout the world. The artificial atom has been a real boon to quantum physicists studying the behavior of electrons, because it gives them a new window into the atom which was not previously available. Because their structure does not rely on the electrons' attraction to a positively charged nucleus, but on electrostatic repulsion and the geometry of P-N junctions, artificial atoms are generally at least 50 times larger than natural ones, and physically overlap with at least 50x50x50 of the natural atoms in the semiconductor substrate. That's an important difference.

Also, notably, the shapes of natural atoms—spherical, dumbbell, pinwheel, tetrahedral, etc,—arise from the purely spherical symmetry of the nucleus' electric field. Quantum dots do not share this characteristic, and in fact many of them are "pancaked," or foreshortened along one dimension. And depending on the shape and voltage of the repulsive fence, artificial atoms can have square or triangular symmetry. Multipart fences with different voltages on each section can even lead to atoms which are asymmetrical.

Another difference with artificial atoms is that the energy of the electrons is a direct function of the physical size of the quantum dot. Ten nanometers is a magic number only because it equates to the de Broglie wavelength of a room-temperature electron. Larger dots can be constructed to house electrons with lower energy, and smaller ones can operate either at higher temperatures, or with voltages applied across their P-N junctions, to kick cool electrons up to the dots' confinement energy. Smaller, higher-energy dots are actually better, because they're closer approximations of real atoms. (With their electron energies low and close together, some of the larger dots exhibit interesting behavior only at cryogenic temperatures.) And by erecting *concentric* fences atop a quantum well, we should be able to create quantum dots with tunable energies (which, as a side benefit, could lead to tunable lasers, long a holy grail of the photonics industry).

This arrangement—an artificial atom of variable energy *and* shape—could be

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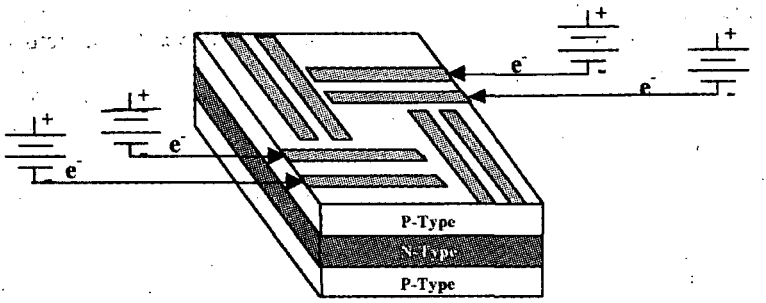

Figure 6: Artificial atom – eight voltage sources

further enhanced by placing a second, identical set of electrodes on the quantum well's lower face, probably with an insulating layer below that (Fig. 6). This would allow the atom's characteristics to be fully adjustable in three dimensions. Even more complex arrangements may be possible, but remember these structures are so small—made of a few thousand atoms at most—that we don't have the sort of broad flexibility we do at larger scales. It's like building with Legos—the smaller you get, the more restricted your design choices.

A final and critical difference between natural and artificial atoms is that nuclear forces limit the number of protons in a stable atomic nucleus to 92, the atomic number of uranium. Unfortunately, since protons and electrons are paired, this means that atoms containing more than 92 electrons are unstable, i.e., radioactive, which makes them annoyingly difficult to use for anything other than bomb and power plant fuel. This is where the real "killer app" of artificial atoms comes in: since they're not burdened with a nucleus, they can remain stable even with *hundreds* of electrons crammed inside, forming gigantic new orbitals classical chemists could never have imagined.

The remarkable properties of these new orbitals have been investigated by (among others) Paul L. McEuen of the University of California at Berkeley, Charles M. Marcus of Stanford University, and Raymond C. Ashoori of MIT. Their finding: much weirdness. Some orbitals exhibit "electron bunching", which permits one or more electrons to slip in and out of the atom with zero energy cost. Larger orbitals are also much more strongly influenced by magnetic fields than small ones are, so that effects can be easily produced which would appear in atoms only at field strengths of a million tesla or more—unachievable with today's technology. And in larger quantum dots—particularly asymmetric ones with large numbers of electrons—the shell structure breaks down altogether, yielding a kind of "mystery atom" with weird magnetic properties. Indeed, switchable exotic magnets may be an important application for artificial atoms.

Clearly, artificial atoms—while remarkably similar to natural ones—are capable of exhibiting a wide range of structures, characteristics, and behaviors which do not occur in nature. In fact, the 92 "natural" structures are tiny and by no means preferred islands in the

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sea of this technology's overall capability. This we now know: "doping" a semiconductor with artificial atoms can modify its physical, optical and electrical properties in decidedly unnatural ways, with decidedly unnatural results.

And remember, the artificial atoms don't just sit there—like simple quantum dots, they interact with their neighbors. We can not only form chemical bonds between them, but also turn the bonds on and off as electrons are pumped in and out. This is virtual chemistry, or pseudochemistry, or artificial chemistry, but chemistry nonetheless. Nano- and microtechnology promise to rearrange the shape and texture of materials, which is great, but not really so different from what we can already achieve manually, with a machine shop or even a simple potter's wheel. Nanotechnology may even be able to rearrange atoms, albeit slowly, like a fungus. But here is something entirely new: a material capable of changing its very substance, instantaneously.

Up to this point, I've stuck close to the existing research, speculating minimally. Interestingly, this also reflects the prejudices of the researchers themselves: despite the obvious and enormous potential of this field, no respectable scientist has stepped into the media limelight to discuss its future goals and benefits, or even its state of the art. Berkeley's Paul McEuen, one of the braver figures in the field, went on record in *Science*, saying "the next step is to assemble these atoms into artificial molecules, and solids . . . which could not be realized with real atoms." Both the statement and its venue, though, are studiously nondramatic.

Why? Because the next few steps sound utterly nuts, like magic, like nothing that any sane government or venture capitalist would want to fund or even encourage. As cold-fusionists Stanley Pons and Martin Fleichman discovered to their woe, premature speculation—especially to the press—is the bane of an otherwise promising science career. Fortunately, there is a profession for whom this sort of gonzo extrapolation is not only acceptable, but actually somewhat mandatory: science fiction writers. It's in this capacity that I'll proceed, and if I start to sound a bit over-the-top, well, that's what they pay me for.

This Way to the Future

To date, I'm not aware of any experiment which has placed more than three artificial atoms together. Nor has anyone placed multiple artificial atoms in anything other than a straight line. This is primarily because our manufacturing techniques aren't up to the task, but it isn't difficult to imagine, say, a one-millimeter-square microchip covered with a grid of designer atoms. In other writings I've used the term "programmable matter" to describe this technology.

In the 1990s, that term actually enjoyed limited popularity in describing the related technology of cellular automata. These are spreadsheetlike computer programs in which each "cell" contains a formula which defines its state as a function of the states of neighboring cells. This turns out to be a great way to simulate phenomena like weather and fluid mechanics, and the "programmable matter" label appealed because the material represented in individual cells could be converted instantaneously from fluid to solid and back again. Walls could be rearranged, or their surface characteristics modified. One fluid could be substituted for another in midflow. But I maintain that this sort of mucking around is actually *virtual* programmable matter, whereas our quantum dot chip is the real thing. So I'm officially usurping the term, and will thumb-wrestle any cellular automatist who wants it back.

Now, spacing of the quantum dots on our chip would be problematic, since they'd need to be close enough to interact, but not so close that the electrodes of one have a major disruptive effect on

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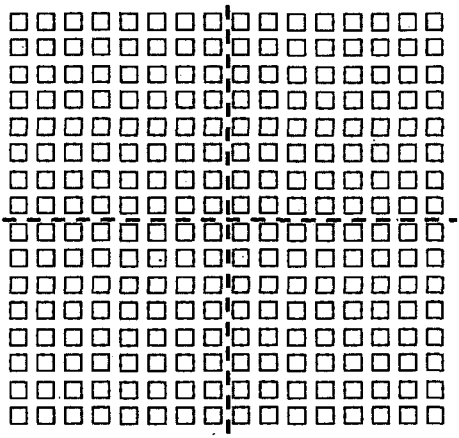

Figure 7: Controlling artificial atoms in groups of 64 requires only 1024 independent voltage sources.

the contents of its neighbors. But let's say for the sake of argument that the whole thing, electrodes and confinement space and safety margins around the outside, is a square 20 nanometers (~100 silicon atoms) on a side. This means the chip will hold fifty thousand rows of fifty thousand dots each, or 2.5 billion (2.5E+9) designer atoms.

Let's further suggest that for maximum flexibility, each dot is controlled by sixteen electrodes with independent voltage sources. This means 16 separate conductor traces feeding into the chip for each of our several billion dots. That's a lot of wires, and a lot of independent voltage sources. Impractical? An obvious simplification is to break the grid up into smaller chunks, say groups of 8x8 or 64 quantum dots. Each of these 64 would be controlled independently of the others, but each block of 64 would behave the same as every other block (Fig.7).

This may sound like a limitation, but if each electrode can be set, for example, to 256 discrete voltages, each designer atom will have 256^{16}, or 3.4E38 possible states. Compared to the 92 states of the periodic table, this is a staggering number, and if we place three designer atoms together, the number of states climbs to 1.02E115, or 10 quadrillion googol. Since my calculator is incapable of processing numbers above 1 googol (9.99999E99), this meets my definition of "effective infinity," and if some fantastic materials-processing machine were to activate and test a million trillion states every second, it would still take almost a googol of years to test them all. So an 8x8 grid—more than 21 times as large—represents an absurd and downright spooky wealth in undreamed-of materials. Finding needles in that cosmic-scale haystack will be the work of lifetimes.

Controlling the chip itself, however, is relatively easy: with 16 electrodes for each of 64 designer atoms, we have a total of 1024 or "one K" signals to worry about. If each of these signals is an 8-bit voltage, then we only need one kilobyte of memory to represent the commanded state of the chip. Since fitting one kilobyte into one square millimeter of semiconductor is a trivial exercise even today, we can simply add yet another

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layer to the bottom of the chip, containing 8192 transistors to serve as bits, and passing 1024 signal traces up to another layer, which parses them up for routing to the individual quantum dots.

No sweat. We've got a chip that's capable of turning into gazillions of different substances, and we're not even breathing hard. Laying a few hundred of these chips out-side-by-side will result in exactly what I promised earlier: a TV screen which changes not only color, but substance. With minuscule power consumption, it could easily switch from lead to gold and back again, maybe a million times a second. And since it isn't limited to the 92 natural elements, it will be capable of taking on characteristics which natural substances can't. It's a safe bet there will be better superconductors than today's yttrium barium oxides, better reflectors than mercury (the shiniest substance known today), better photoelectric converters than silicon, etc. In my novel *The Collapsium*, I even go so far as to posit the existence of programmable matter "superreflectors" and "superabsorbers," which reflect or absorb/convert light in a given frequency band with 100% efficiency. It isn't so farfetched.

Really, such chips would be capable of doing and being so many different things that it's easier to start from the other end, and list off their limitations. They can't change their mass. They can't change their shape, although they can be mounted on the surface of something which can. They also can't self-replicate, although they can presumably be mass-produced by a sufficiently advanced nanotechnology. Also, while their "chemical" properties are real, they're not straightforward—the atoms of the semiconductor substrate don't simply go away. At best, you'll have an atomically thin programmable layer sitting on a bed of silicon or gallium arsenide. At worst, you'll have discrete programmable islands jutting up from the substrate like stones in a Japanese garden.

Too, since their electron orbitals are 50 times larger than in a natural atom, they won't interact with natural atoms in a natural way. Presumably, clever choice of quantum dot settings could permit bonding between artificial and natural atoms, but even so, the spacing of the quantum dots is a major limiting factor. For example, we could tile the chip's surface with ersatz glucose molecules, but

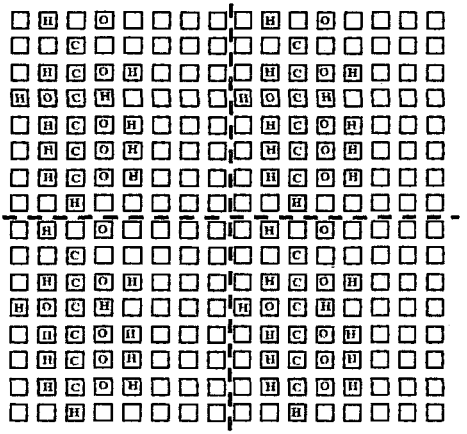

Figure 8: Making it sweet?

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these would be so oversized that our taste buds would never recognize them. Still, if we really want the chip to taste sweet (Fig. 8), or sour, or like filet mignon, I'm confident that future engineers will find some dot settings which approximate it. With multiple, asymmetric orbitals to play with, they may even find ways to make a quantum dot behave like two or more atoms simultaneously.

A final important shortcoming of this technology is its lack of 3D structure. The programmable layer is a nanoscopically thin veneer on the surface of the chip, capable of mimicking only two-dimensional molecules. This rules out the vast majority of organic substances, inorganic crystals, and nanomachine components. You can't command a diamond coating to appear on the chip, or even a quartz one. Fortunately, this limitation has a rather simple solution: we roll the chip around into a long, thin fiber (Fig. 9). With the P and N and P layers of the quantum well, and the conducting traces on top of them, and the memory and insulation layers beneath, this fiber would have a minimum thickness of around 60-80 nanometers (300-400 atoms), meaning we could fit 10-13 artificial atoms around the circumference of it, and a potentially infinite number along its length.

Once we have these fibers, we can string them up in a three-dimensional lattice, not unlike the skeleton of a building, or else weave them together tight as basket wicker. This is a tough nanoassembly job either way, but once it's complete, we have artificial atoms bumping right up against one another, able to bond with neighbors on the same fiber and/or adjacent fibers. Now we can create not only a thin film of goldlike pseudomatter, but a three-dimensional solid with the *mass* of wickered silicon but the physical, chemical, and electrical properties of an otherwise-impossible gold/silicon alloy. Or mixtures of other metallic or nonmetallic substances, including the "unnatural" and "impossible" ones discussed above. And with the flick of a bit, the voltages on the quantum dots can be altered, to change the solid from one miraculous pseudosubstance to another.

In a heated discussion on this subject in the hot, hot summer of 1998, I and Dr. Gary E. Snyder of Pioneer Astronautics coined the name "quantum wellstone" (or simply "wellstone") to describe this hypothetical but quite plausible form of programmable matter. It's a term which has served me well in my fiction, and which others are welcome to use in the same capacity.

If some pesky tunneling energy problems can be solved, a functioning block of wellstone could also serve as a strong, diamondoid material, and in fact where diamond is formed when carbon bonds covalently with four neighbors in a tetrahedral or pyramid shape, artificial atoms offer so many more electrons to play with in so many more ways, that we can almost certainly create pseudomolecules with double or triple or even quintuple covalent bonds between multiple designer atoms on multiple threads, leading to materials which are tougher than diamond by orders of magnitude, though only when "turned on" by minuscule electric currents.

Anyway, imagine an automobile constructed of such programmable matter. Or a house. Or an implantable prosthetic skeleton. Wellstone provides more than simple access to "impossible" physical states; it provides the ability to *change* states simply by shuffling electrons around. Bones and bulkheads could be indestructibly strong at one moment, springy-soft and compliant at the next. Electronic devices built of wellstone could not only use the quantum dots themselves as very small transistors, but could instantly lay out circuit traces capable of changing from conductor to semiconductor to superconductor to insulator.

This kind of dramatic and instantaneous effect is serious Clarke's Law

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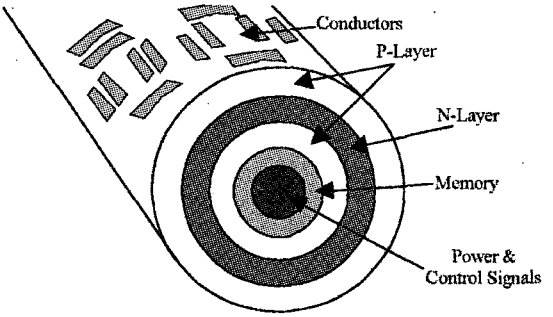

Figure 9: A wellstone fiber

mojo—virtually indistinguishable from magic. I'm frankly surprised the idea hasn't found its way into more science fiction, since it's actually a much handier plot device than the ever-popular nanotechnology. It will probably be 10-20 years before the first programmable matter chip is built, and another twenty before anything like wellstone becomes anything like possible. From there, it will take still more time before the technology diffuses out into mainstream society. But when it does—even if it's only a fraction as capable as I've hinted here—its transformative effects will be staggering, like falling through a closet into the land of Narnia. Make a magic wish, my friends, and if you're still alive in fifty or a hundred years time, you may find you're wizard enough to grant it yourself!

About the Author:

Wil McCarthy is an aerospace engineer, science columnist, and the author of six science fiction novels, including the New York Times Notable *Bloom*, and Amazon "Best of Y2K" *The Colapsium*. He has published three short stories in *Analog*: "The Dream of Houses" (1995), "The Dream of Castles" (1997), and "The Dream of Nations" (1998). This is his first nonfiction appearance in *Analog*.

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ALTERNATE MARKETING

Alan L. Lickiss

Warren saw his friend Jonathan already seated at the table as the maître d' led him through the dining room. Friends since college, even though they had chosen different career paths they still met once a month for lunch. Normally going dutch, Warren was picking up the check today. It was the least he could do for his friend who had saved his butt, and saved his company millions.

The smells of broiled steak and butter-drenched lobster had Warren's mouth watering as he took his seat across from Jonathan.

"Pretty snazzy place you picked. Sure you can afford it?" Jonathan asked.

Warren looked around, admiring the Victorian décor. "No problem, thanks to you," he said.

"It really wasn't that big a deal. My company made a pretty penny on the excavation contract, and I got a nice bonus."

A waiter appeared at the table to take their order. Part of the ambiance, and expense, of the restaurant was the all-human staff. Not even a robo-bartender.

"That reminds me," said Warren after the waiter had taken their order. He pulled a white envelope from his jacket and slid it across the table. "That's the payment for your company's invoice. I thought since we were having lunch I'd hand-deliver it."

"I'm glad to see that," said Jonathan. "That's my bonus."

"Your bonus? But that is the entire contract fee. How did your company make any money if they are giving you the entire fee?"

"The company made a lot of money on the back end of the deal," said Jonathan.

"Back end? What back end? It was a simple excavation project to clear and grade a dirt road up a mountain, and to dig a foundation hole for the observatory at the top. The inspectors got back a

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couple days ago and they say the site is perfect and ready to begin building. What kind of back end could there be?"

Their waiter arrived with their garden salads. Jonathan swallowed a bite before he answered. "When you put out a request for a proposal on this project, you got bids from several engineering and construction companies, right?"

"Yes. While we didn't go with the lowest bidder, we got what we thought was a good price from a reputable company," said Warren.

"But it turns out they were falsifying progress reports to keep invoicing, burning through ninety percent of the budget before they were found out."

"Don't remind me," said Warren after swallowing a bite, enjoying the tangy taste of the French dressing. "When I tried to find another company that could do the job, the bids were even higher than before. Even the robotic equipment construction companies wanted five times our remaining funding."

"And that's the difference between how you looked at the problem and how my company looked at it. You looked at it purely as an engineering project. We're a marketing company. We looked at the problem as a marketing problem."

Warren looked at Jonathan, his fork stopped halfway to his mouth. "What are you talking about?"

"Let me ask you a question," said Jonathan. "What would you say if I offered you a thousand dollars to live in the middle of nowhere for a month and spend all your time shoveling dirt?"

"I'd call you a lunatic," said Warren.

"Exactly. But what if instead I offered you the opportunity to be part of a select group of people at a fitness camp in the pristine beauty of the Colorado mountains? And the cost for the four-week program was a mere five thousand dollars?"

Warren stared at his friend. "Oh my god, I'd probably be interested."

"You engineers are always saying you try to think out of the box. Well, us marketing guys are the ones who designed the box." Jonathan pulled out a trifolded brochure from an inner pocket and handed it to Warren.

Pioneer New You Jumpstart

Revolutionary new program for a more healthy you, focusing on the work and eating habits of the pioneers that made this country great.

Warren read through the promises of the brochure that expanded on what Jonathan had already said.

"We hired engineers to oversee the project, and a staff of personal trainers and dieticians. We charged people five thousand dollars to participate, and guaranteed they would get results."

Warren handed the paper back. He shook his head. "I can't believe that worked."

Jonathan finished the last bite of his salad. "We set them up in camps away from civilization and junk food. We fed them lots of nutritious food, worked them hard, and made sure they got plenty of rest. You'd be amazed at the improvement some of those people saw."

"But the road, the foundation hole," said Warren, trying to fathom what he had been told.

"A thousand people can move a lot of dirt, one shovelful at a time. Like I said, it's all in how you package the product."

Warren gaped at Jonathan. His eyes shifting back and forth as his mind worked to find words, any words to say. Finally he picked up his drink, raised it in the air, and said, "To package marketing." ■

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Choosing Life

Brenda Cooper
and Larry Niven

Life is a series of transitions and transformations—but where does it end?

"I'm going to try this. Christa, I have to. I can't face ending. I go in tomorrow for the first mapping."

His hand in mine felt papery, insubstantial. I knew the hope that would carry him forward into this odd choice, knew he'd become like morning fog to me, gone into dreams. I swallowed hard, said simply, "It's OK, Rafe. I've always allowed you to do what you want."

"I know." He squeezed my hand, the soft embrace of an older man comforting a special friend. It brought him from fog to physical. Deep moments always turned up my senses; the soft crackle of new fall leaves became louder as we passed into a dry spot under the trees, and I could smell the water of Lake Sacajawea. A cool wind lent pinkish color to his white face and I pressed closer to him, seeking warmth. "They've tested this," he continued, "It's been ten years since old Ray Kurzweil became the first. They say I'll be smart like when I was twenty; I'll be able to think better, to remember things. I'm going to write articles about what it's like to become myself in a new form."

"The ghost in the machine." I meant it to be a comfort, but the words were edged with my own fears.

"Better than just a ghost. I like the butterfly image better."

"I'll miss walking with you." I ducked my head low into the damp, hid my face from him.

"I can leave you messages."

"You'll forget me."

"No. How could I forget you?"

Where Rafe was going, time moved faster than real life. He'd feel ten years for my month. There was no way to respond—people need to hold whatever illusions mean something to them.

"Look, Christa, we're about half machine already." He pointed to the box on my belt, the dots all showing green to indicate health. The light on the end pulsed evenly with my heartbeat.

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"You're full of computers so small you need a microscope to see them. Me too. It's just another step from nanodocs to being digital."

"This digital thing is in fashion with the kids," I offered helplessly, as if that would keep Rafe from wanting this. "We're so old we never even fell for rap music. Neither of us is pierced, and we don't tattoo our faces."

"We exercise. We do yoga. We fell hard for wrist reporters and then nano," he said simply.

"There is that." If it would keep us alive longer, we chose it. But I wouldn't choose this—it just wasn't human. I'd rather just die when my time came.

"What are you afraid of? Wayne and Ali are OK."

In some sense, sure, the Constant Companions were OK. There had been a ceremony that wasn't called a funeral, but ashes had been present. We had email that said they were happy, loved their new work, and we should come join them and be young again. It sounded like a postcard from Puerto Vallarta, but someone else already lived in their old apartment. I preferred to think they had simply moved away.

I said, "I've never been much of a computer type. Oh, I use them, but what would it feel like to *be* one?"

"Now, Christa, you know they say you don't become a computer. You live inside one. That's different. You feel, well, like yourself. And hey, if I don't find out, I'll feel nothing soon."

"I know, Rafe. I know." We never said *dying*. Does the butterfly leave behind a dead caterpillar? I glanced at his waist. His belt recorder showed green and yellow, the heartbeat light fast yellow. Alarmed, I slowed down.

We finished our daily path around the lake without talking much. Rafe pointed out a blue heron, and we watched it glide low and sharp until its fine angles intersected the fog and it turned to shadow, then mist, then nothing.

He invited me over for the evening. I had thought romance mostly behind us, but he had made a good effort. A four-inch pillar candle was centered on the table, flanked with new tan placemats. Round wooden leaves held russet cloth napkins. When I fingered one of the little yellow leaves he told me he had carved them, and he would leave them for me if I wanted them.

There was potato soup, topped with real cheddar cheese that melted into orange rivers on the white peppery potato surface. He had also made bread, and cut it precisely using a long sharp knife engraved with his name and his last wife's. It said *"Jeanne and Rafe, forever, May 12th 2022"* in fine curled script. I knew that forever had been ten years, until she died of a cancer that would have been cured if she'd chosen nanomedicine. We dipped the bread carefully in the soup, laughing companionably as warm potato dripped from the crust onto our chins.

Rafe kept a library of classic videos. He chose the original Judy Garland version of "The Wizard of Oz" and we curled up close on the couch, spooned, as if we were young enough to be lovers. His arm lay over my thick waist and he rested his palm on my breast, unmoving, a warmth, comforting. My back leg caught in between his longer legs below the knees so we were one tangled being. I smoothed my thin gray hair to keep it from being in the way of his breath.

As the movie in front of us burst into color, I heard him murmur softly that all of the actors and writers and cinematographers were dead. I said maybe they'd gone over the rainbow, and he replied that maybe he would go there soon. I asked if he could take ruby slippers. He said he thought not.

We parted after a long wistful hug and a single soft dry kiss on the lips. As I left, he dropped the little yellow leaves into my palm, as if his arthritis-thickened hands were tree limbs.

When I woke up the next morning, I

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thought about his choice for a long time. I had forgotten to ask him which digital world he was joining. I knew of one for design engineers, one for historians, and one filled with biologists. There was even a world for performance artists and musicians—there were ads in my weekly updates from the Musicians Guild. The ads referred to us as "biologicals" and inferred we'd be shown up musically by the "digitals." It mentioned the recordings of groups that had gone wholly digital, and released new work that was doing well in the charts.

There were singers doing digital work who'd never released a song when they were physical. One was a still-famous mathematician.

Eternal digital life was probably within my means.

I read Guild literature to keep up on insurance benefits, but of course I read other sections too. No one I'd recorded with had been mentioned for a long time.

After a series of rather creaky slow sun salutations to pull me into the world, I climbed up the stairs to Rafe's apartment to ask him which world he'd picked. The door was open, the super standing in it so I couldn't see around his broad back. He turned at the sound of my steps, and shook his head at me.

"Rafe?" I asked, even though I saw the answer in the super's face.

"His heart gave out last night, Christa. I saw it on my monitor when I woke up. The paramedics will be here to take him soon. But I guess you can go in."

I did. He was lying on the couch where we had lain together just hours before. He looked empty and small, his thin bones curled into themselves and no breath in the hollows of his cheeks. I recalled the heron fading into mist. After standing there for a bit, I sat down next to him and waited silently for the paramedics. The lights on his monitor were all red and blinking, the only thing moving in the room except the super's shadow on the wall. A few more weeks and he'd have been part of a machine. Not my dream, but at least his own. Now he had nothing, was nothing. Empty.

I didn't cry then.

Every day I walked as quickly as I could manage around the lake, feeling that if I moved fast enough the shadow of his death could not catch me.

Every day for a week, until the morning I woke up cold and shivering with fever. My monitor showed yellow lights mixed with green. It looked like Rafe's had. The diagnostics said I had the flu. Only flu . . . but I spent two days hardly able to move. No one called.

By the third day, the nanodocs had got it cleaned out. I went to the lake and walked around as best I could. Just half way around, my breath was so shallow I needed to sit down. I found a bench engraved with the names of dead people, nestled in bare elms very near the lake bank. The surface of the water rippled in response to a cold wind and I pulled my coat close about me. I had talked about moving south to sunshine for thirty years and yet I had never gone, pinned in place by my love for the lake and my few friends, half of them dead now. Eventually Rafe held me here also. He would walk with me every day, taking on summer heat, months of rain, and sometimes a light dusting of soggy northwest snow.

I was healthy enough; there might be a thousand more days I could walk the lake. Maybe more. It looked like I would walk most of them alone. Could I do that?

Could I really take becoming sicker and older with no human help?

Would a digital world be less lonely?

My stomach tightened with these thoughts. I didn't want them. They twisted into the shadows I'd been trying to out-walk, and made a sour taste that crept up my windpipe. The bench felt insubstantial and I held its edges with palms down, slowly breathed into myself, fighting to focus on the breath more than the fear.

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There would be no stepping backwards. New laws said that no one could live in both the physical and digital world. A form of population control, it fell squarely in the middle of the long battle about assisted suicide. The courts had blessed it. But what if you died there? What if there was a bug in your program, your recorded self? How could I do this thing?

As with the nanodocs: in the end there was nothing to lose. There is something compelling for the old in dreaming of being young again. The risk grew while I waited. Like Rafe, I might miss my chance.

Piles of papers had been signed for weeks, wills discussed, and then the thing could finally be done.

The first mapping session was too small for so significant a passage. It was a like a regular doctor's visit. They placed me on a bed in a smallish room with static flowered wallpaper on two walls and a full-sized wall-screen built into the third, playing an obnoxiously calming ocean scene. A nurse came in and attached two tiny electrodes to my temples with clear sticky gel, pushed some medicine and instructions into my nano-monitor, and I drifted to sleep. Hours later, screeching seagulls invaded the ocean scene and woke me up. I felt exactly like myself, creaky and a little disoriented.

As I sat up the nurse came in and removed the electrodes. She helped me wash, smiled, and said that the doctor would be along soon.

Doctor Nelson was half my age, purple and silver tattoos shimmering on her cheeks as she bounced in. I managed a smile as we did introductions.

"I'm pleased to tell you that you tested OK. Your brain and nervous system are healthy for your age. In fact, you're a really good candidate. Now, has anyone explained this procedure to you before?"

I nodded.

"OK, well, I'm going to do it again so I know you've heard, but I'll keep it short."

She looked at me expectantly, so I nodded again.

"People are essentially patterns. You are a different pattern, in your brain, than I am. All of our cells change regularly, but our pattern changes only as we change and grow; as we learn. Your pattern as a child of seven was more like your pattern now that you are eighty-seven than my pattern would ever be like yours.

"Now, these patterns, mine and yours, are stored in our nervous systems, primarily our brains, but some of it runs all the way through our bodies. We can read the arrangement of neurons in your brain and nervous system and re-create it as a singular entity inside of a computer. It's not a program, any more or less than you are a program now. In fact, it works like you do now, but faster. It works like you, is you, in perfect health."

"So while I slept you read my neural patterns? So you have a re-creation of me in the computer now?"

"Um. Now, we did scan you. And we fed that into a holding area, a place we test personalities before we release them into one of the net communities. For you, that's the Avon Bards Performance Group's net that is full of other accomplished singers and musicians, with some others who chose to opt in because they want to learn or just love music—"

"Or think they have talent." Been there, done that. "So there's a copy of me stored in a holding area?"

"Let me finish, Christa. No, there isn't. We can't have two conscious Christa Alexander's at once—it's illegal. So while you slept, we tested the 'download' and then erased it."

At that, she got quiet for a minute, and fiddled with the wall screen controls.

"Something more active please," I asked. "Maybe something with birds and

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wind and rain."

She smiled at that. "Most Northwesterners want to see sunshine—scenes from California or the southwest."

I pushed away the thought that they had just murdered . . . something. Not *me*. I pulled at my hair quietly, testing to be sure I was physical. I was.

"So," I asked, "what happens next?"

"Well, now we know it's possible. Your final appointment is set up a week from now, and in between you'll meet with an outside counselor. They deal with affairs and legal issues—and you met at least one of them before you got this far."

I nodded.

"So, when you come back, you'll be scanned just like today. A new scan, so you'll remember what went on during this next week. That time, we leave the body asleep, and the new Christa will wake up digital."

She waited for me to say something, but I didn't.

She continued. "You'll have a body. A perfect one. Digital, but the 'self' needs a body to interact with, at least so far. The new Christa will get to explore for a time—weeks by your measure, while being kept in the holding area. There will be help for you there, and the rest of your questions can be answered. Some questions can't be answered until you have the context for them, it can't be helped." She was talking fast. Maybe she had another patient waiting.

"You'll be in holding for hours, or less, by our measure here, and we'll let the old discarded physical body sleep. Then the electronic version of your personality makes the final choice. Stay or go."

"But I've already made the choice," I stated.

"It has to be done this way. Partly, so we know that you, the electronic you, are complete. Then we put the old body to sleep permanently. Many new digitals say it's like trading old clothes for new, except better, indescribable."

"You do hear from them, then?"

"Yes. They communicate with us quickly. Lots of data, actually. That's why so much, for example, new music, in such a short time. This has only been an approved procedure for two years, but half the music you can buy is made by digitals. It's the time difference. But remember, that makes *our* ability to communicate with digital people much harder—it's slower in that direction."

I hadn't known about the music, about how much was digital. Probably I hadn't wanted to. Maybe that was something to run towards, like loneliness was something to run from.

I smiled at the doctor and went out, heading for the lake and the cold biting wind.

The week went in fits and starts. I wrote a long letter to those few family members I knew well enough to even remember, revealing my choice, not explaining why. Sometimes I stopped in unlikely places to run my hand over physical things. In a grocery store, the roughness of a tangerine, the cool beads of moisture resting on bottled juice. Each day I went to the lake. The last day I sat and cried on its bank for hours, savagely loving the pain, the damp shivering, and the cold knife-edges of the grass under my palms. That day I brought the fine wooden yellow leaves that Rafe gave me, to fling them in the water. Instead, I arranged them artfully on an empty bench by the playground, hoping some living woman would find them.

The next morning I dutifully performed my sun salutations before dressing. Mountain pose, inhale, reach for the sun, exhale, and come down, right foot back, and on. Tightening muscles, stretching tendons in places where, eleven years ago, I hadn't known there were places. I'd taken up yoga after the nanodocs got me out of the wheelchair.

I dressed carefully. As I left my empty apartment I threw away my nightclothes. The six-block trek to the clinic took years.

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I went in alone. There was one last paper to sign. My hands shook as they signed the Death Warrant.

The procedure was the same small thing. The only difference was my fear as I lay down, sharp and edgy. I wanted to know these last moments with all of my senses, to be alive until the drug swept me to sleep.

I wanted the lake. I wanted earth falling through my fingers as I bent at the feet of ripe corn. The wind as I ran. The awkwardness of early yoga coupled with the release of savasana pose. Joy of singing. Joy of singing.

My eyes opened. Shut. Colors, bright, and yes, eyes open, yes so bright.

"She's waking." A soft whisper, as if it came from all around me.

Back, back to savasana. Closing my hands, wriggling my toes. Sitting up. My hands swept into Namaste, eyes open. Perfect rounded nails with white moons in them. Smooth pink skin, the blue veins of age become memory. I took a deep breath, moved one flawless hand to my stomach. It kept going as if my stomach were insubstantial, then landed on smoothness, on the concavity at the end of an exhale.

It wasn't me. My stomach wasn't so flat, my nails were ragged. I was . . .

"Is she ready?"

"I don't know. Patience."

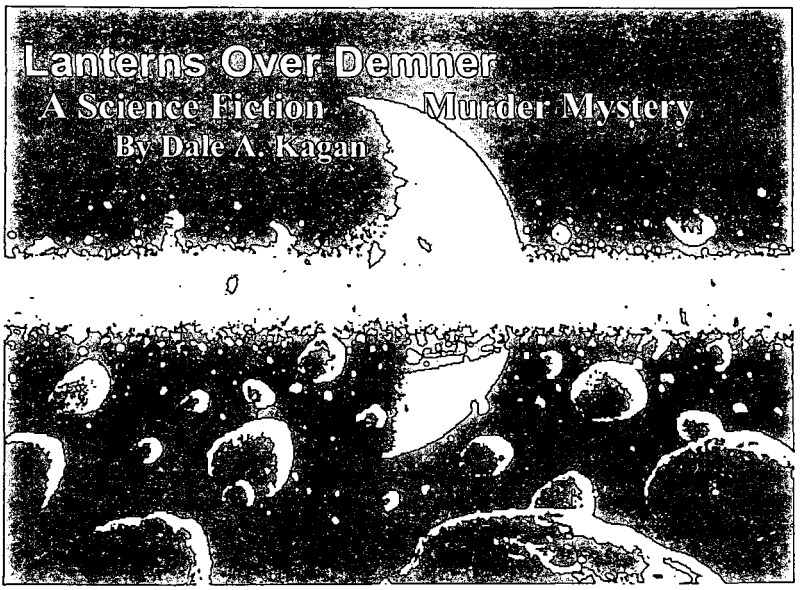
I spoke. The voice was different, silkier, but still my words. "I'm awake. I'm afraid."

"Of course."

"We'll help. We know."

"We know."

"Welcome, Christa."□



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BEHIND THE SCENES AT *DYKSTRA'S WAR*

By the time this column appears, my novel *Dykstra's War* (available from Baen Books) will have been on the stands for about a year. Some of you will remember the character of Dykstra from two longish stories that appeared in *Analog* in 1993. One was called "Sunshine, Genius, and Rust," (May) and the other "Young Again" (December). "Young Again" finished second in the AnLab in the novella category that year, so I gather many readers liked it.

Both stories are set in the future of about a century hence, and involve first contact with a peculiar and warlike race. The aliens, called the Phinons, are more advanced technologically than humanity of that time, possessing an FTL drive that humans hadn't even thought was possible. The *Analog* stories end just as the critical breakthrough is made to understand how humans, too, might build an FTL drive.

These two stories make up the first quarter of *Dykstra's War*. These stories and the novel have prompted questions and observations from some of my fans. In this column I intend to "explain myself" to a limited extent, about how I came by the character of Dykstra and the science and technology for which he is responsible. Granted, this column *is* a bit self-indulgent on my part—what writer doesn't like to talk about his work? But I hope that in sharing these bits about what I did, some of you writers to be out there might find it either helpful or reassuring. (In my case, one sentence by Stephen King in his introduction to the long version of *The Stand* is what turned me into a professional writer. So you just never know.)

In my fictional future, James Christian Dykstra is an old physicist responsible for the "best understanding" of the laws of physics in his era. I based him on three different physicists, and a bit on myself, both on how I am and how I would like to be. I made him old because I've always rebelled against the idea that the great physicists only do their best work when they're young. Einstein published his first paper on Special Relativity when he was in his twenties. But his greater work was the General Theory, and that didn't get published until he was in his thirties. Suppose that Einstein had been successful in formulating the unified field theory he worked on for the rest of his life? Would we not then recognize the value of an exceptional mind working on a problem for many years? In Dykstra, I have a character who burns to convince the world that he "still has it," but also struggles to convince himself.

Much of the technological background for *Dykstra's War* I thought up long before I wrote the book, some of it originating as early as my pre-teen years. I wanted my future history to have force shields, artificial gravity, repulsors, and faster-than-light drives. I started reading books about relativity theory when I was in 7th grade, so I knew these wonders didn't look possible with known physics.

And I worried about that. I couldn't stop thinking about how such technology should work, and I also began figuring out how the different technological wonders were related to each other. Couldn't a repulsor just be artificial gravity working backwards? And could a shield be a

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repulsor-type device where, say, a billion gravities worth of repulsive force is confined to a thin shell around the projector?

To get to the new physics, I simply invoked a paradigm shift, and made Dykstra responsible for that shift. Of course, with any paradigm shift, old data and experiments don't disappear, but the way we understand them changes. Right answers gained via the old theory have to continue to be the same right answers with the new theory. And even the new and exotic technologies made possible by the new physical understanding are going to have to run on 60-cycle AC. OK, that's not quite true, but you get the idea. Even a hyperdrive will be built out of metals mined the old-fashioned way, and controlled by electronics bought off the shelf.

Despite my veneration of Einstein, the three physicists I actually based Dykstra upon are Isaac Newton, Richard Feynman, and Nikola Tesla. In my future, the paradigmatic theory of physics is Dykstra Field Theory. The only physicist prior to Dykstra whose work so dominated physics is Isaac Newton himself, the founder of Newtonian mechanics. Though Einstein cast a very long shadow through the physics of the twentieth century, his role is not quite as overarching as Newton's has been, even to this present day. Also, Newton was a theologian as well as a physicist (in addition to being a mathematician and an alchemist). I drop hints in the *Analog* stories and in *Dykstra's War* about Dykstra's connections to a particular religious denomination called the Calvinist Reformed Church. But *Dykstra's War* was not the vehicle in which to explore those issues, so I'll leave that to another time.

The next famous physicist is Nobel laureate Richard Feynman. Feynman was known for being not just a brilliant physicist, but also a "magician," able to pull rabbits out of hats when it came to physical insight. This trait Dykstra also shares. But it wasn't this ability alone that made me want to connect Dykstra with Feynman. For that, one needs to read *Surely You're Joking, Mr. Feynman* to find the colorful character that was Feynman. From bongo playing and womanizing, to his no-nonsense approach on the *Challenger* panel, Feynman was anything but the stereotype of the typical physicist. Feynman knew how to play, and he knew how to live life to the fullest. But he also knew great sorrow, as one comes to discover when reading the frustrating account of his wife's death. Feynman did original and valuable work across a wide spectrum of physics, and even into the little realm of nanotechnology. I portray Dykstra as much the same kind of generalist.

And Feynman was oh so deliciously *quick*. There's a story about how Feynman was giving a lecture and talking about how weak the gravitational force is. He said, "It's not just weak, it's damn weak!" At that moment, a light came crashing down from the ceiling of the lecture hall. Without missing a beat, Feynman added, "Weak, but not negligible." It is not always fair to equate a quick wit with intelligence. Niels Bohr was supposed to be a notoriously slow thinker. But Dykstra is one of the quick kind.

Finally, Nikola Tesla. There's some question about calling Tesla a physicist. For the most part, he is thought of as an inventor, with the induction motor, the AC power system, and radio amongst his credits (Tesla's prior claim to the invention of radio over Marconi was recognized by the U.S. Supreme Court in 1943). But he does have a unit of magnetism named after him, and this is in recognition of the fact that Tesla was also a wizard at making electricity do weird and wonderful things in an era when gas lamps and candles still dispelled the darkness. Tesla was to electricity what Mozart was to music, a prodigy with unmatched talents in what we today would better describe as experimental physics. So I wove a bit of Tesla into Dykstra, because I wanted a polymath who could not just think up theories, but test them as well, inventing new equipment in the

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process to do so.

Unfortunately, Tesla was also rather strange, although I'm not honestly sure just how strange he was. A huge mystique has grown up around Tesla and his technology, and a great deal of what one can read about Tesla and his inventions is pure crap. Tesla was an excellent writer, and it is best to read Tesla himself before wading into the other material.

One other bit of information about Dykstra might be of interest, and that is how I came by the name. "Kooistra" is often thought a Dutch name, but here in West Michigan, the Dutch side of the state, it is known that "Dutch names" ending in "ra" or "ma" are almost always *Frisian*. Friesland (or Vriesland) has only been a part of the Netherlands for a few hundred years, and we Frisians are more closely related to the other North Sea peoples than to the Hollanders. I wanted my scientist to have a characteristically Frisian name. Around the time I thought up the Dykstra character, which was in high school, the movie *Star Wars* came out. (Two years earlier in a sophomore composition class I wrote a story called *Star War*. Missed it by *that* much!) The camera used to produce the spectacular (for their time) special effects in *Star Wars* was called the Dykstraflex camera, named after the inventor. Dykstra is named in his honor.

Many writers create future histories, and two of those most noted for it are Heinlein and Larry Niven. In my case, Niven was the most influential. In commenting upon his future history, Niven points out that inventions available early in the chronology have to also exist in stories set later, or at least be explained away. Although my future history shares the same problem, I have another problem with which I need to come to grips.

But first, since I brought up Niven, readers who wonder about how much a science fiction writer can influence a 15-year-old boy's mind for the rest of that boy's life should read *Dykstra's War* and then Niven's "The Borderland of Sol" which appeared in the January, 1975 *Analog*. Therein, one finds ships that use hyperdrives (but hyperdrives that can't be used too close to a star); a company called "General Products"; and asteroids out beyond Neptune. In my book, one finds hyperdrives that won't work inside something called the Hague Limit (i.e. not too close to a star); a company called "Capitol Products"; and lots of asteroids out beyond Neptune. With this last, it is true that since 1975, lots of Trans-Neptunian objects (TNOs) have been found, and I've long thought (ever since Chiron turned up between Saturn and Uranus) that the outer Solar System must have lots of rocks strewn throughout it. But I liked the way Niven used such real estate in his stories, so I put them in mine.

Anyway, back to my problem.

It was all well and good that as long as I was making up the science, then all I needed to be concerned about was internal consistency. Each story in the future history could only violate the same known physics in the same way each time. But since working on those earlier Dykstra stories and the book, I've come to have a different feeling about the physics. For instance, I now think it is altogether likely that the speed of light can be exceeded without any appeal to hyperspace, using the correct formulation of aetheric mathematics. This amounts to a return to classical mechanics and electrodynamics, but in a more complete form. (See my columns "Aether One or the Other" (March, '00), and "Five Predictions for Century 21" (July/August, '00).) I also think this same understanding will make real gravity control possible, but I'm not so sure about those shields yet.

So I have to make a decision: Consistently stick with the fun but false physics I invented for my future history, or find a way to put my new ideas into that history?

Hmmm. My next novel in the Dykstra Universe takes place about a hundred years later. Seems like that should allow ample time for another paradigm shift. ■

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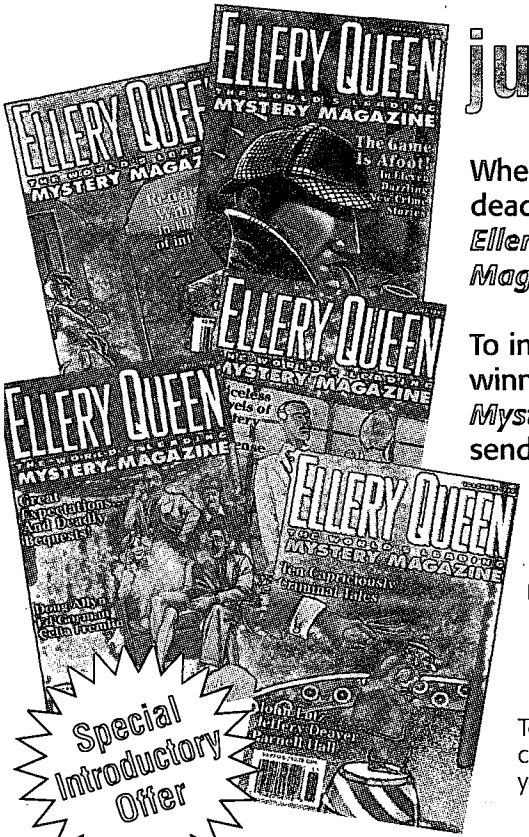

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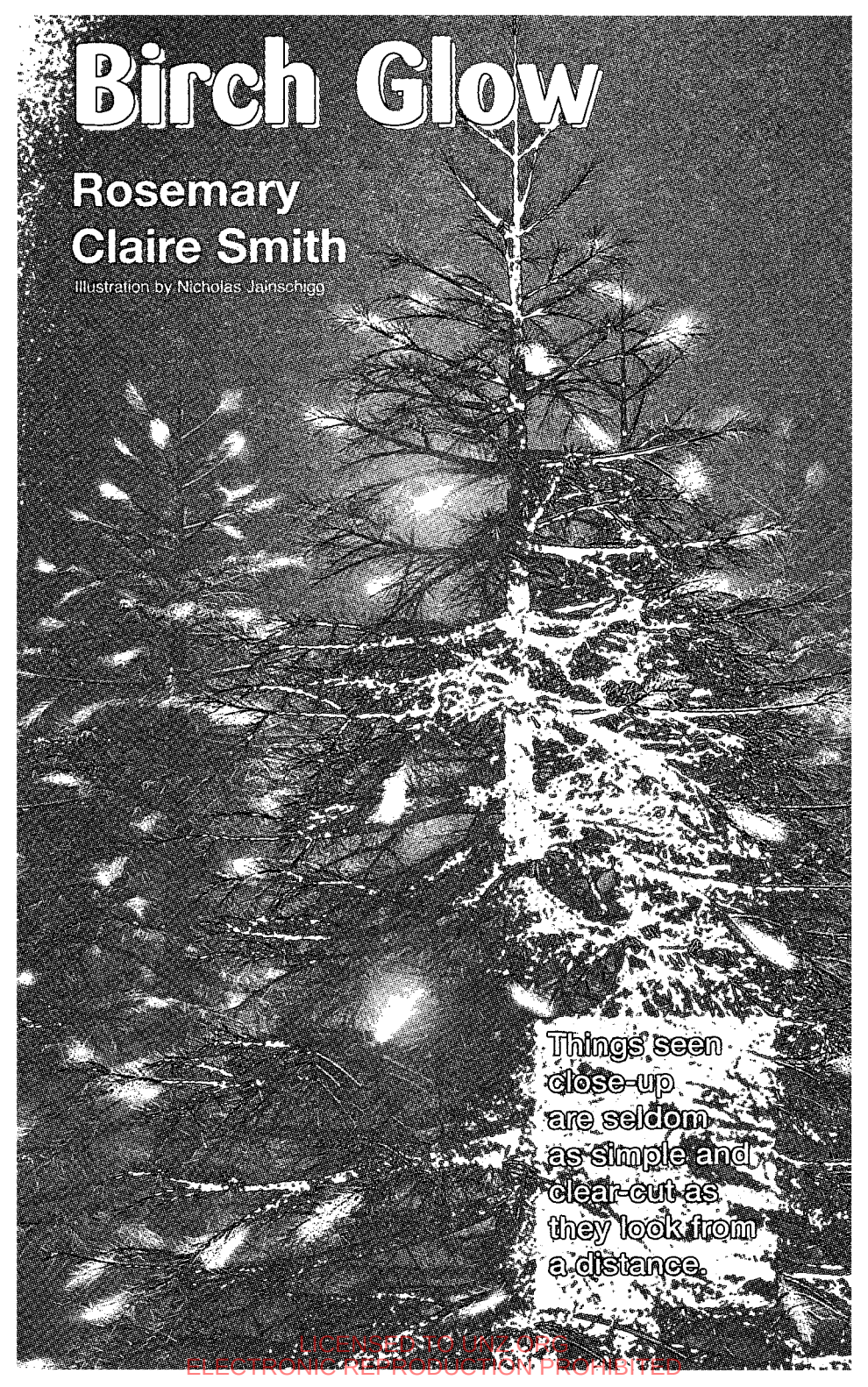
Birch Glow

Rosemary Claire Smith

Illustration by Nicholas Jainschigg



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Who would ever think that a staunch individual like me could get into such a mess because of peer pressure? Or was it all caused by my unrequited love for a beautiful girl? At the time, I believed loyalty was what made me sneak off into Vermont's Green Mountains with my eco-purist buddies. In the dead of night, we set out to chop down as many trees as we could. We'd considered torching them, but a fire could get out of control.

I bounced along in the back seat of Midnight Gypsy, thinking I really should be back in my dorm room doing my bio homework. Next to me, Eric O'Toole hummed a nuevo-jazztech tune popular on UVM's campus radio station. Danielle rode shotgun. Naturally, Mastodon was at the wheel of his 20-year-old SUV, which he'd retrofitted to run off electricity, driving as though the acid fog didn't limit his vision one bit.

"What if the cuffers catch us?" I blurted out.

"Shit, Jason, who's gonna see us in all this fog?" Mastodon eyed me in the cracked rear view mirror. That's not his real name, but at 6'5" and 325 pounds, it suited him a lot better than his given name, Martin Priest. When I was eight, his family moved into a house a block from mine. He was ten and big for his age. The first time Mastodon saw the neighborhood bullies make fun of my poor soccer playing, he folded his arms across his broad chest, widened his stance and gave them a frown that scared them into silence. I've looked up to him ever since.

"Just hypothetically," I said, not sure how far to push it. "Will your eco-purist friends pay our bail?"

O'Toole smirked at my mistake.

"Environmental restorationists," I hastily corrected myself. Only the media called them 'eco-purists.' "Will they help us out?"

"Of course," Mastodon said. "You want to be part of the solution, don't you? I mean, you can't just loaf around sending email to your dick-face congressman and think you've done some good. Those biofactured trees are a skutting menace."

Except for Mastodon, the others didn't know my family had been getting a seven-foot Balsam Glo Christmas tree for the past three, four years now. This being my first semester away at college, the thought of coming home for Christmas made me jack happy. A part of me needed to smell that Balsam Glo and run my fingers along its papery white bark. Most of all, I needed to watch that tree glitter red and gold as we all sat down to Mamma's turkey, roasted under a layer of bacon strips, and spiced with onions, garlic, sage, and rosemary.

Danielle peered through the white haze. "Turn here," she said.

Mastodon took the turnoff from the state road and Midnight Gypsy began to climb. Our equipment shifted in the back.

"You're not going to chicken out on us, are you?" O'Toole eyed me with suspicion. In the semester I'd known him, I had figured out that O'Toole believed everyone was either for him or against him. No in-between. But Mastodon liked him, maybe because of O'Toole's willingness to act on his commitment to restoring the environment.

"It's too late to change your mind, anyway." At least Danielle's voice held a hint of sympathy. No point in wishing her voice promised more than that for me, since she'd been Mastodon's girlfriend for over a year.

"I'm not backing out," I said. "We've got to stop those mutants from outcrossing with wild firs and birches." When the balsam/white birch hybrids interbred with either species, they passed on the firefly genes.

"Damn straight," Mastodon said, evidently satisfied with my devotion to eco-purism. "Before we know it, they'll jump the lake and invade what's left of the 'Dacks. They're already colonizing

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New Hampshire and Quebec." He had started as a biochem major before switching to communications.

As we rounded a curve, the fog suddenly thinned. Mastodon pointed out the driver's side window. "Look at that."

I glimpsed a stand of white birch saplings. Their yellow-gold leaves had fallen two months earlier. They reminded me of spindly headstones marching up the hillside. Or they did until the tips of their bone-thin branches began flashing red, purple and orange. I shivered.

"Luciferase," O'Toole said with disgust. "The name says it all."

He meant the enzyme produced in a firefly's photocytes that enabled the bug to glow. A generation ago, the gene for the luciferase enzyme had been successfully spliced into a harmless bacterium, thereby enabling luciferase to be produced in the lab. But it was only recently that the gene was successfully spliced into the balsam fir's DNA sequence. Of course, they claimed that the new traits couldn't spread to other species, but here was clear proof that they lied.

"You still believe in Satan and Hell?" Danielle clearly enjoyed goading O'Toole.

"All I'm saying is the Pope was right. Those trees are unnatural. Sinful. We ought to take them all out." O'Toole had spent twelve years in a boys' Catholic school outside Boston. Twelve years of indoctrination against corrupting the species God set on Earth. I never figured out why the Church didn't care about the previous 2000 years of plant breeding. Hadn't Gregor Mendel been a monk?

Mastodon said, "It's not as though they're fooling with genes to cure human diseases. Those dick-faces are skutting with nature to produce self-lighting Christmas trees."

Pebbles pinged off Midnight Gypsy's undercarriage as we climbed above the last traces of the fog.

Mastodon glanced up where something fluttered in the trees overhead. "That's another thing. They're driving the pileated woodpeckers to extinction." It had been widely reported that the birds refused to mate in the presence of the flashing lights. What's more, they wouldn't even nest anywhere near a glow tree.

"They probably can't get a decent night's sleep with all that flashing." I was thinking of yesterday's all-nighter, and tomorrow's too. Finals were coming up.

After another couple of miles, we passed a sign saying, "ENTERING BALSAM PLANTATION, HOME OF BALSAM GLO™, THE FINEST IN HOLIDAY TREES," with arrows to the visitors' center and tour bus parking. The visitors' center perched like a wannabe ski lodge on the hillside. Inside the plate glass windows, several ten-foot Christmas trees blinked red, blue, green, yellow, orange and purple, like demented renegades from a shopping mall. Farther on, a big sign said, "WARNING—PRIVATE PROPERTY; AUTHORIZED EMPLOYEES OF BALSAM PLANTATION ONLY BEYOND THIS POINT."

We ignored it.

As we drove past a flatbed truck, parked by the side of the road and half loaded with flashing Christmas trees, Mastodon and O'Toole glared at them as though they were leaky barrels of toxic waste. I gave them a frown, too.

We pulled up to a locked gate and parked. Now came the tricky part. A twelve-foot-high fence of electrified wire mesh enclosed the processing sheds, the seedling nursery, and acre upon acre of blinking evergreens. Danielle had already hacked into the company's computers and come away with the security codes. She had boasted of her ability to disable the system and let us enter and leave without a trace. I suspected she came along more for the challenge than out of any true environmental zeal.

While Danielle and Mastodon were working on the control panel built into

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the gate, O'Toole covered Midnight Gypsy's license plates with a couple of rags. We probably should have done that a few miles back, but no one thought of it. I wandered over to look at the propaganda displayed on the signs for the tourists. With all the twinkling, I could read it without a flashlight. They said the yellow-green firefly color was developed first. The real breakthrough was the reds and blues. That let them biofacture trees with the traditional Christmas colors.

"Hey, Mastodon." I couldn't resist needling him. "They say that Balsam Glo trees withstand the effects of acid rain lots better than natural balsams."

"But what they don't tell you," Mastodon said, "is that the mutants produce *less* oxygen than unenhanced firs."

O'Toole smirked at me, pretending he'd known that all along.

"Because they devote their energy to glowing," I admitted. "But still, isn't it good that they can resist pollution?"

Mastodon had all the answers. Without any hesitation, he said, "Hell, no. They're opportunistic—like kudzu and zebra mussels and killer bees. They invade the territories of the red spruces and sugar maples, which have already been weakened by all the acid rain and acid snow."

"And you can't trust the government to protect natural trees," O'Toole said. "Ever since ultraright politicians gutted the environmental laws, look at what's happened."

I thought of all the freak ice storms in the last dozen years. Worse yet, the ecopurists pointed out that bluejays, pileated woodpeckers, red spruce, and sugar maples would all be on the endangered species list if the list hadn't been abolished.

Mastodon nodded. "That's why all true environmental restorationists have no alternative but to take matters into our own hands."

"Got it!" Danielle exclaimed. "The perimeter fence is off."

Mastodon punched the code into the latch. For a couple of seconds, I held my breath, certain that the alarms would start shrieking.

Nothing happened.

Mastodon swung the gate open. Triumph filled his face. You'd think we would have whooped like we'd just done a dose of Joy Ride. Instead, it was dead quiet. As Mastodon stepped inside, the frosty ground crunched beneath his feet like cereal. The challenge in his eyes pierced us. O'Toole swaggered after him, then Danielle, who looked exceedingly proud of herself.

Not a trace of fog remained to hide our deeds from view. I swallowed my apprehension and followed. At least, the four of us were in this together.

We carried the axes, the handsaw, and the cans of black paint we had unloaded from the back of the old sport ute. Danielle cradled the brand-new sonic saw, which she had borrowed from her parents' vacation home in Stowe. O'Toole eyed it, and Mastodon, too, but I doubted Danielle would let any of us get our hands on it.

"This one's first." Mastodon stopped in front of a six-foot balsam that twinkled silver and gold.

Danielle switched on her parents' toy. With a barely audible hum, the sonic saw turned day-glow orange.

O'Toole frowned at the garish device. "What the—?"

"That's a safety feature," she explained as she touched it to the base of the tree. The saw tore into the papery white trunk, spitting wood chips and sawdust back at Danielle. The mutant balsam shuddered and toppled, crushing several branches as it sank with a soft sigh. Silence coated the hillside.

I pried open a can of paint and sloshed some on the middle branches of the downed tree. That was to prevent the plantation owners from simply selling the Christmas trees we felled. Back

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in Mastodon's dorm room, Danielle had come up with the paint idea. But we also had to chop them down so that they wouldn't live to spread the firefly gene.

"Do the next one," Mastodon commanded, stamping his feet. "It's too cold to spend all night here."

"Just how many are we going to take down?" Danielle asked. There must have been thousands.

"As many as we need to make a statement."

I picked up an ax and another paint can, and crossed over a half dozen rows. After choosing a tall balsam with a nice gap in the lower branches, I swung the ax. Thunk. It made a satisfying sound as the blade bit deep. I levered the blade loose and swung again. Thunk. And again. The exertion soon brought the blood flow back into my hands. By the time I had leveled three trees, I'd worked up a sweat and was feeling considerably more relaxed about our enterprise.

The noise of a gasoline car motor stopped me in mid-swing.

"Shit!" Danielle swore.

"Jason! Come on!" Mastodon was barreling down between rows of trees with Danielle and O'Toole at his heels. The light from the newcomer's headlights swept over the balsam grove as the vehicle rounded the bend. Right behind it, a second car was coming for us, too.

Clutching the ax, I charged after my friends. Midnight Gypsy looked impossibly distant. As I ran, I accidentally clipped a branch with the ax. It threw off my stride. I stumbled and fell to my knees.

I looked up to see the others had reached the SUV. Two sets of headlights were closing the distance.

Mastodon started the engine.

"Wait!" Danielle was tugging on Mastodon's arm and pointing back at me.

I scrambled to my feet and began sprinting. With a crackle of electricity, the perimeter field leaped up between my buddies and me. I skidded to a stop. Panic hammered in my skull, drowning out the small voice that said, 'Just stay calm.'

"Go! Go!" O'Toole shouted to Mastodon as he shoved Danielle into Midnight Gypsy and dove in behind her. The door slammed.

The sport ute roared forward, spitting gravel. Mastodon swerved around the oncoming cars, then skirted the perimeter fence. He came to an old, washed-out logging road and plunged down it.

I whirled around and dashed back toward the biggest trees. Had to find a thick one to hide behind. Tomorrow morning they would turn off the fence. I could sneak out with the tourists. It would be tricky with the trees lighting up the place, but with a little luck—

"Freeze!"

Before I could do so, what felt like a tub of cold, wet mud hit me from behind. Tangle gel. Already, the stuff was hardening on my back and legs. I tore at it with my gloved hands, having lost the ax. My struggles threw me off balance. I tumbled face first into the dirt. The tang of evergreen needles filled my nostrils. I tried to kick, but my legs felt like they were bound by a thousand icy ropes.

Rough hands rolled me over and I stared up at a rent-a-cuffer. The weasel gave me a jack-happy smirk and said, "I'll get a bonus for catching you."

A state trooper strutted over to us, reached into his jacket pocket, and dug out a card. "Listen up. You have the right to remain silent . . ."

They scheduled my trial right after New Year's. It was a miserable Christmas, between my dismal grades on final exams, my mother's tears, and my father's lecture about what a disappointment I was, to say nothing of the seven-foot Balsam Glo that hogged the living room in front of the picture window. I went for a walk during the tree-trimming party, and still couldn't manage to

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get away from the skutting things. Everywhere I looked, there were Balsam Glo trees in living room windows or planted in back yards.

I called Mastodon several times, but the Christmas week passed and he was never home, or maybe he thought the line was bugged and I'd give him away. A few days before New Year's, I walked over to his house. He came outside and we sat on his parents' snow-covered patio furniture.

"Listen, you've got to get in touch with your eco-purist network to raise money for my defense—"

"Already tried that." Mastodon shook his head. "They all said yours is a worthy cause but none of them have any cash to spare."

"Shit." I balled my hands into fists. "If you could see the public defender I'm stuck with. The nervous spinach-brain told me this is only his third trial, and he lost the other two."

The public defender wanted to get me a plea bargain in exchange for turning in my friends. I had thought it over, but I couldn't rat on Mastodon. He always stuck up for me when we were kids. He wouldn't have driven away without me if he'd had a choice. Although I would have happily fingered O'Toole, who had been all too ready to leave me behind, he might name Mastodon.

"Can't your parents come up with the dough?" Mastodon asked me.

"Their cash went to pay my out-of-state tuition and the bail bondsman. How about Danielle? Her family can afford the best lawyer in the state."

"They're vacationing in Portugal." Mastodon looked glum. "Jason, stay away from her."

"But—"

"It's too risky—for her. Look, we'll both get in touch with you in a few months, when this dies down." For the first time ever, I saw fear cross his face.

The prosecutor was one of those perfectly manicured women who knows she's smarter than everyone else and always has to win. Each time she spoke, the public defender gripped his pen real tight and looked grim. I was too shell-shocked to remember much of the trial, except that the public defender tried to convince the jury that there was no evidence I'd chopped down those trees and that they could have been cut by someone else before I got there.

I was sentenced to three years of community restorative justice. Nice sounding concept, whose origins date back to the days when people thought enlightened sentences involving community service and restitution to victims of crimes would do convicted felons some good. By the time I learned about the program up close and personal, the system was rigged to give jack-happy deals to big business.

My sentence was auctioned off to Balsam Plantation Tree Farms and began the following week.

I straightened my back and pulled off my work gloves to rub my hands. After weeks of digging irrigation ditches and pulling weeds, the calluses across my palms had thickened nicely. You'd think Balsam Plantation would have used a backhoe for the job, but they claimed it was cheaper to pay minimum wage than to invest in fancy equipment and a person with the skill to run it. Ditch digging wasn't any worse than lugging fifty-pound sacks of fertilizer and mulch, which was my other principal task. Back at UVM, my friends would be celebrating spring break this week. I hadn't heard a word from any of them, not even Danielle.

"Good morning, Jason."

Dr. Foster plodded toward me, her rubber boots sinking into the muddy ground. The grandmotherly geneticist was the only one of the corporate lifers who talked to me like I was a human being. The woman at the front desk, the tour guides, Plantation Manager Dean,

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and the other employees all treated me with suspicion, if not full-blown contempt.

I smiled and waved to her. Everyone liked the diminutive white-haired scientist who brought the staff home-baked peanut butter cookies and told stories of the old days before they'd even mapped the human genome.

"I have good news for you."

"They commuted my sentence?"

"Hardly." Dr. Foster gave me a wry smile. "What would you say to a less strenuous job as my lab assistant?"

I suppressed a snort of amusement. "Mr. Dean would never agree to that."

"It took some doing, but I persuaded him." She held up her arthritic hands. "As you can see, I'm losing my ability to do precision work. The company won't pay the going rate for a trained lab assistant. But since you're a bright young man and know some of the basics, Mr. Dean reluctantly agreed to give you a shot at it. But he wants you to know that if you ever try any funny business, you'll spend half your life in prison. So what do you say?"

I hesitated, picturing how Mastodon would react if he were here. He would probably accuse me of aiding and abetting the enemies of the Earth. But he wasn't the one digging ditches.

"Jason, I hope you're not waiting for a better offer."

"It's nice of you to think of me, but I don't . . . What I mean is—how can someone like you propagate those evil—"

"Nonsense," she said sharply. "Gene splicing is no different than the grafting, hybridization, and the genetic selection methods farmers have been using for centuries. Nowadays, we take more precautions than at any time in human history. We've learned from past mistakes."

"No more DDT?"

"That's right."

"But what about the glowing birches? Your company claimed the firefly genes couldn't spread from the firs to other species." Seeing her look of dismay, I pressed on. "Aren't the new mutants as opportunistic as zebra mussels? Look around. They're already invading the territories of other species that have been weakened by too much acid rain."

"We've made some mistakes," Dr. Foster admitted. "Normally, genetic enhancements can't be transmitted to unrelated species. But what we failed to take into account was that we transformed the Balsam Glos into first cousins to the paper birches."

"You did?"

"We spliced in birch genes to speed up growth and to give the balsams that papery white bark that's so wildly popular. It's not generally known, but we also borrowed quite a number of other useful traits from the birch family including the ability to enrich the soil with calcium, potassium, magnesium, and phosphorus. But I believe the transgenic *Betula papyriferas* probably won't survive. You see, the energy they devote to flashing lights probably places them at a competitive disadvantage."

I shook my head. It was easier not to have to decide which side was right.

"You don't believe me? Let me show you something." She grabbed my hand and led me to the seedling nursery. Amidst rows of newly sprouted balsams were scattered handheld computers and other equipment. "Here we go." She picked up a thick log book and began paging through it. Seeing my expression, she explained, "I always preferred paper records. Now take a look at this summary chart."

I glanced through the columns. They demonstrated that substantially higher energy inputs were needed to maintain mature Balsam Glos. But the eco-purists claimed the biofacturing companies lied. And yet, Dr. Foster didn't strike me as the kind of person who would fake lab records.

"Why take unknown risks just to make a profit from prettier Christmas trees?"

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"Jason, we're not merely creating prettier Christmas trees here. We can't ever count on the politicians to protect our evergreens from acid rain."

"That's for sure."

"So instead, we're trying to breed new species of spruce, fir, and pine whose needles and cell membranes and root systems will be more resistant to sulfur oxides and nitrogen oxides."

I gave her a skeptical look.

"It's just good business. The company can't afford to have half its product die before harvesting. You'd be helping to create hybrids that are less vulnerable to insects, disease, drought, and frost. Now how about it?" She smiled her grandmotherly smile.

"But the sugar maple and the red spruce are close to extinction. Pileated woodpeckers, too."

"You got me there." Dr. Foster threw up her hands in exasperation. "We don't have all the answers. Those are harder problems, but I'm working on them—especially the sugar maple. Do you want to help me find a solution or not?"

Mastodon wouldn't approve. But he might be wrong about the balsams. On the other hand, perhaps I could eventually figure out if there were mistakes in Dr. Foster's methodology.

"Yes," I said.

The day after Thanksgiving, I was working late in the Balsam Plantation lab, recording soil nutrient figures for the latest batch of *Abies balsamea lampyria*—Balsam Glos. It felt good to be using my brain again and contributing to a scientific study. Maybe someday I really would finish up that biology degree. When I ran the comparison with unenhanced *Abies balsamea*, the difference in nutrient levels in the top three centimeters of soil was pronounced. Concentrations of calcium, nitrogen, phosphorus, magnesium, and potassium were all up substantially. The difference was so striking that I immediately double-checked the numbers and got the same result. I called up the figures for the two different breeds at two, five and ten-year intervals. If anything, the news just got better as time went by. Figures spun in my head.

I switched to the databases for *Picea pungens*, *Pinus sylvestris*, and a dozen other species. With mounting excitement, I saw clear evidence that Ms. Foster was on the right track! By replenishing key nutrients in the soil, Balsam Glos would pave the way for the stabilization of other conifers, and hardwoods too. Who knows, maybe the red spruce and sugar maple could make comebacks. Why, if enough acreage could be restored, the pileated woodpecker just might survive!

The familiar whine of an old SUV shifting gears jerked me out of my concentration. Midnight Gypsy. I hadn't heard the sport ute in almost a year, but I recognized the sound instantly. My hand went to the alarm button—and hung there. The transmission noise grew louder, closer.

After our break-in, security had been tightened and closed-circuit cameras installed. I rolled my chair over to the backup monitors in the corner of the lab. One of them showed the night watchman in the security office with his feet up on the console. Sound asleep, as usual.

Until this moment, I had relished my newfound responsibility. Starting on my first day working in Dr. Foster's lab, my coworkers had gradually begun to accept me. Maybe it was my susceptibility to peer pressure again, but I enjoyed fitting in.

The headlights and the motor cut off. This time, the license plates were already covered. The flickering monitor linked to the gate showed three figures wearing ski masks get out and look around. I recognized Danielle's striking figure and O'Toole's self-righteous swagger. Mastodon must have put another forty pounds onto his massive frame.

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Why didn't I hit the alarm? I longed to savor the sweetness of seeing O'Toole's panic-stricken face as he lay on the ground looking up at a sneering cuffer reading him his rights. But I couldn't let the same thing happen to Mastodon or Danielle. I stared at the monitor screen, trying to will her to wander away from the others so I might warn her before the security guard woke up.

How was I going to explain this tomorrow? I could hardly say I was so engrossed in my work that I didn't see or hear anything. Would they believe I held off to find out if the perimeter defense was still vulnerable? In theory, the Balsam Plantation computer techs fixed the problem after the last break-in, but you never know.

Danielle and Mastodon went to work on the gate. While keeping an eye on the monitor, I pulled out a tank of tangle gel and placed it in easy reach next to the door. The sleeping watchman had a gun. I was glad I did not. I shoved the remote alarm trigger in my pocket. It would work from anywhere on Balsam Plantation.

Suddenly, the status display screen turned red and flashed, "Warning. The electricity to the perimeter fence is off."

Shit. Danielle had broken the code faster than before. The electric mesh couldn't be reactivated from here. I should push the damned alarm button.

Danielle unloaded her sonic saw from the back of the SUV, then handed an ax to O'Toole. Mastodon reached in and grabbed a satchel. He opened it and pulled out a propane torch. Danielle put her hands on her hips and began talking animatedly to Mastodon. The monitor had no audio, so I couldn't hear what she said. Mastodon made an angry gesture and evidently began to argue with her. O'Toole grabbed Mastodon's arm and nodded toward the lab building.

Mastodon turned and headed my way. O'Toole followed. Danielle stood frozen inside the gate, then hurried after the other two. Apparently, Mastodon and O'Toole must have decided that cutting trees was a dramatic gesture, but ineffective. Torching the labs would seriously set back the research.

I decided to make my stand in the doorway, foolishly thinking I could talk them out of it by showing them the lab records. When Mastodon was a half dozen strides from the door, I swung it open, then jammed my hands into my pockets so he couldn't see them shaking.

"You!" Mastodon's eyes widened in surprise.

I realized he had never bothered to find out where they sent me. Some friend. I clenched my fists.

"Jason!" Danielle gasped. "I was so worried about you."

Before I could stop it, my anger at Mastodon came out at Danielle. "So worried that you never got in touch with me, not even once?"

"I tried to when I got back from vacation." Her eyes flashed. "Your email address stopped working. I called your parents' house, but they wouldn't tell me anything." Then in a softer tone, "What happened to you?"

"Balsam Plantation bought my sentence."

"You work for those skutting bastards?" O'Toole's face held contempt.

"I get it." Mastodon chortled. "You're sabotaging them from within. Tell you what. If you give me a hand, I'll let you come away with us." He lit the propane torch.

"That's mighty thoughtful of you, after getting me into this mess in the first place. If I had only had the money for a decent lawyer—the money you said the eco-purists would—"

"You see, Mastodon, we can't trust him." O'Toole gripped his ax. It was a threat.

"Stop it," Danielle said to O'Toole. "He didn't rat on us before."

"You got a better idea?"

She glared at Mastodon's propane torch, then turned to me, "If *all* we do

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is chop and paint trees, you won't give us away, will you?"

Dr. Foster's face sprang into my mind. How could I ever explain it to her if I shirked my responsibility to save our experiments? Maybe these balsam hybrids weren't the total solution, but they were a giant step in the right direction. They had to be protected. I felt the rightness of that in the pit of my stomach.

"Of course he will." O'Toole began circling around to my right.

"Look, you're making a mistake." I gulped a lungful of frosty air. "The glow trees can withstand acid rain better than other species. They enrich the—"

"The plantation's turned you into a pure blond-brain," Mastodon snorted.

Danielle smothered a giggle. That tore it. I could take Mastodon's superiority, and even O'Toole's baiting, but I wasn't going to be laughed at.

I reached for the tank by the door, but Mastodon was almost as quick. His bulk makes people think he's slow. He isn't.

I drenched him with the tangle gel. He bellowed in surprise or pain. Before the ropes hardened, he managed to slam me back against a table. My vision dimmed as agony lanced through me. Mastodon lost his balance and his shaggy skull smacked into a work bench. Petri dishes and equipment flew in all directions. He collapsed to the floor, his head coming to rest on the broken glassware. A few inches from Mastodon's hand, the gel-coated propane torch sputtered out.

A second later, O'Toole was coming at me with the blunt side of the ax.

"No!" Danielle screamed and yanked him away at the last instant. He whirled toward her. She switched on the sonic saw. They stood frozen, glaring at each other for a long minute.

I pointed the tangle gel sprayer at O'Toole and squeezed the trigger. He danced to the side and it doused Danielle instead. She gasped. O'Toole wrenched the sonic saw from her hand and shoved her struggling body at me. Instinctively, I reached out to catch her with my free arm. O'Toole turned and fled.

Already, the gel rope was hardening around her—binding my arm and my left side, too, which were pressed against her. Danielle felt ice cold and her fragrance filled my nostrils. I ached to kiss her. If only she'd ever given me the smallest hint that would be welcome. Instead, I said, "I'm sorry I yelled at you before. You weren't the one I was mad at."

Danielle was staring down at Mastodon like she hadn't heard me. "How could you do this to him?" Her teeth chattered.

"He'll be all right," I snapped.

With my free hand, I set down the sprayer and groped for the remote alarm in my jacket pocket. It was partially gelled shut and I had to rip the fabric. The whoop-whoop-whoop of the alarm jolted the night guard awake.

"As soon as the watchman applies the dispersant," I said to her, "you'll start to warm up." Midnight Gypsy's engine roared to life. "The cuffers should be here in about five minutes."

"Too late," she replied. "O'Toole's getting away." The sport ute's motor gradually faded as it tore down the gravel road.

"He may think he is, but the surveillance cameras captured the whole thing. And if we both testify against him . . ." Seeing her troubled look, I stopped.

She whispered, "You wouldn't testify against Mastodon and me, would you?"

Mastodon and me. I shut my eyes. "Don't ask me that."

The cameras had recorded every detail, but I still intended to do my duty. Maybe a high-priced lawyer could get them off on a technicality. If not, I supposed they might be sentenced to work on a tree farm. I hoped it would be one far away from me. ■

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Perceptual Set

James Van Pelt

The interpretation of indirect evidence may say as much about the observer as about the observed.

Illustration by Vincent DiFate

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Margo said, "If you really want to know how a man will treat you, watch how he eats his cheesecake."

Janet poked at her dessert. "That's ridiculous." The second shift filled the cafeteria. From their table near the wall, the narrow room curved up to the other end as it followed the mining and processing ship's long arc, but Janet's attention was on Crew Chief Alec Maier. She noted he'd chosen the cheesecake too, but he ignored it as he listened to a pair of his miners arguing about relief time and compensation for lost work. He never glanced her way.

Janet put her fork down in disgust. "You can't make a decent cheesecake with rehydrated dairy products. I should have had lunch in my quarters."

"Did you get new scans on the Gargoyle?"

"Where did you get that name?" Janet whispered. "A Strieberist will hear you, and I'll be fending off missionaries again."

"Nut cases. If they had their way, we'd give up on the whole ark project and wait for rescue instead."

Janet remembered how the recruiters sold her on graphic presentations of the ark ships heading for the stars, fleeing the mutagen-wracked Earth, packed from end to end with everything necessary to colonize distant planets. Without the asteroid-mining projects, the arks would never be built. They had needed her cartography skills, and now she was the go-to person in the department.

"Maybe, but they see alien fingerprints on everything. I don't care what the company says about hiring diversity. They make my life miserable. You're not supposed to know anything about it anyway. It's secret," Janet said.

Margo dipped a piece of bread into her coffee cup, then popped it into her mouth. "People talk to me. I'm the therapist." Like most of the crew, she'd long ago given up on the regulation work clothes, wearing instead a loose tee shirt and shorts. Her hair was a close-cropped brown that matched her dark eyes. She grinned while chewing. The only time Janet saw her with a serious expression was when she studied psychiatric profiles. Then, her brow would wrinkle and she'd push her fingers into her cheeks as if trying to squeeze understanding out of herself. "So, is it an alien space station?"

Janet thought about not answering, but Margo's security clearance was higher than hers, and if she really wanted to know, there'd be little Janet could do to stop her. "No, but it's darned weird. The clearer the scan, the more it looks like a head to me, just like the Ceres flyby recorded." The first clear photos showed a face on the asteroid. At first it seemed as if it was *all* face, but later shots showed it was more like a cameo carved into a larger surface. She'd enhanced the images, then turned in her report.

Margo snorted. "Head, my foot. It's your perceptual set. Giovanni Schiaparelli thought he saw water channels on Mars in the 1800's. He was *prepared* to see evidence of life, and he found it. It's like that head on Mars obsession at the end of the twentieth century. Put three dots and a line on anything, and people turn it into a portrait. That's called 'feature extraction,' taking info you're familiar with and ignoring the rest. A water stain sits on a wall long enough; someone sees the Virgin Mary. Do you ever notice the Virgin Mary doesn't show up on walls in Buddhist countries? This asteroid is no different from the rest, an odd-shaped rock we can run through the mill for metals, fuel and chemicals. The Ceres flyby takes a long-range shot by accident, and third-rate administrators with more imagination than good sense turn shadows and a jagged protrusion into an alien artifact. We're taking a tedious trip for nothing, and I'll be dealing with disappointed alien-hunters for months."

"The main office doesn't think it's nothing. You don't divert an entire mining operation on a whim."

Margo said, "Maybe not, but you're on

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a deadline. If you don't figure out exactly what it is before we get there, the radicals will get the upper hand. There's more than one Strieberist in administration."

Janet watched as Alec pushed his dessert to the side and started sketching on his napkin. The workers leaned over his shoulder so they could see what he was doing. She admired the way he concentrated while writing on the small surface.

"He's monofocused," said Margo.

Janet turned away. "You're the monofocused one—I'm not watching him. The probe should be within ten kilometers in an hour. We'll get even better pictures then."

"Sheesh, it's a half a kilometer long. How close do you need to get before you see it's an ordinary object?"

"That's another thing. The Gargoyle has almost no albedo. I mean, most asteroids are darned dark anyway, .03 or so, but this one's a lump of coal. If it hadn't occluded Ceres, we would have never seen it. That's not natural."

Margo shrugged her shoulders. "A black asteroid, big deal. There, now look at that one." She lifted her chin toward a miner at a near table. He wore his coveralls with a strap down. Sweat marked his shirt in a pattern mirroring his work suit's pressure points.

"What about him?"

"Watch the cheesecake."

Janet thought the man had a rugged competence. Like most miners, he carried the ship's spin-induced gravity carefully, as if he wasn't sure that anything he set down wouldn't drift off. He pulled the plate with the cheesecake toward him. Then keeping one hand on the plate, he trimmed a third of the slice off with his fork, lifted, swallowed, took the second third, lifted, swallowed and finished the last third, all in fifteen seconds.

"Whew!" Margo said. "That was businesslike."

"What does it tell you about him?"

Margo raised an eyebrow. "Isn't it obvious? He doesn't take time for the finer things in life. A woman would be wise to steer clear of him."

"Maybe it means he was hungry. You're a loon."

"And you think a football stadium-sized rock has been shaped into a head. So how did Alec eat his?"

Janet turned to look back at the crew chief, but he and the two miners who'd been arguing with him were gone. His cheesecake sat untouched.

Margo said, "You work with him all the time. Why you have to turn it into such a big deal now that you've decided you're interested is beyond me. What do you guys talk about on those long jaunts in the jalopy?"

"That's business. He's thinking about where the operation will anchor. I'm thinking about navigating and mapping. There's nothing romantic about riding the jalopy from the ship to the next mining site."

"You can't read clues into his every behavior . . ."

"You just told me to look at how he eats his cheesecake, for crying out loud!"

Margo went on, ignoring the interruption. "Yesterday he asked you to pass the salt, and you spent the next two hours deciding what it meant. Tell him you think he's cute."

"I'm thirty, not sixteen. Maybe you could tell him."

Margo laughed. "Oh, that's very thirty. If you give me a note, I'll pass it to him."

Janet looked at her suspiciously. "Does he ever talk about me?"

Margo shrugged. "Maybe."

"I should have never kissed him," said Janet. "He doesn't like surprises."

"He saved your life!"

"Yeah, and there's that, too."

In the cartography lab, Janet shuffled through the new prints. Chief Cartographer Lindsey London held one in her lap, biting her lip.

"It's difficult to ascribe these formations to natural forces."

Janet put a half dozen scans on the

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table end to end, each one revealing a different look at the asteroid as the probe passed. "Those aren't formations, they're features. It's a face. Two faces, actually, one on each side."

Lindsey stood so she could see the entire set. She was a severe woman in her fifties, rigorous in habit and demanding. She cleared her throat, then rubbed her forehead. Like many on the ship, she suffered from sinus infections. "I suppose it would be hard not to draw that conclusion. They do look like faces." She moved a print closer to her. "Darned ugly ones too."

With enhancements, the asteroid's edges were clear, the shadows and highlights easy to distinguish. Janet turned the photo so the orientation made sense to her. On the asteroid's edges, jagged spikes jammed so tightly there appeared to be no space between them. They crossed each other in random arrangement. With the probe close, details stood out. Janet estimated each spike might be ten or fifteen meters in diameter at the base, although she couldn't see where they anchored, and none were shorter than fifty meters as they tapered to blunt points. Were they crystal structures? What could cause this? If the entire surface was covered with the spikes, it would be difficult to land. There was no place a ship could put its legs down for a secure anchor. In the spike field's middle, however, the face filled a third of the surface. It rose from the pointy surface, a nearly perfect ovoid.

Janet turned the photo again, squinting at the new angle. "I don't know about ugly. It looks scared."

Lindsey glanced again. "If it is an alien face, how would we recognize its emotion?"

"How *else* would you describe that?"

The mouth was reptilian and gaping, stretching across the ovoid's bottom, a dark, crooked gap. A slit where the nose would be, and the eyes thrust wide open, like two almonds far apart, pupils dug into the spherical surfaces. Janet squinted at the photo, trying to see it without the starry background. "I don't know what makes me think it, but this is a frightened expression. Whoever carved it knew what fear looked like."

"It's not the same on the other side." Lindsey handed her another scan.

Here the mouth bared huge, stone teeth. The eyes were narrower. Janet shivered. It reminded her of a dog she'd tried to pet once, until its lips curled back and the snout became all fangs and a shuddery growl.

Janet said, "So, are you still going to argue this isn't a manufactured object?"

"I'm not telling the company we've found an Easter Island head in the asteroid belt, but I'm willing to say it's anomalous and deserves further study. Until then, no one Earthside knows about this."

Janet raised an eyebrow.

"Not my decision," said Lindsey. "Word from upstairs. Even on board there aren't a dozen people who know why we've changed our schedule."

Janet started an accelerated animation of the odd object on her computer. It revolved so the two faces alternated. The fearful expression rotated past, the shadows stretched across the stone skin, darkening the mouth, shifting shadows across the eyes so for a moment, they seemed to move. Then the spiny border filled the screen. The fearful face's profile cut across the stars as the second face rotated into view.

"It's a solid hunk," said Lindsey. "Not a rubble pile."

"That's my guess. I read the light bouncing off it—there's darned little—and it comes up nickel-iron. No magnesium. Some iron-silicates."

"Nickel-iron should be brighter. Why's it so dark?"

The second face came into view. As frightened as the first one looked, this one threatened. The same alien features. A different emotion.

"Maybe it's painted."

Lindsey didn't laugh. "Send the probe

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down to get a sample from the surface of a face. Keep it away from the spiky areas. There *might* be a coating, or it could be just a dark ore, a type of asteroid we haven't observed. If there are others with this little reflectivity, we might never see them. While we're waiting, get a complete map worked up. We're going to want to anchor the drills and mill."

"Has anyone considered the asteroid might be a message?" Janet swallowed dryly. Lindsey didn't like her orders questioned. "If it is artificial, whoever put it there didn't want it to be seen, and if it was seen, they didn't want it to look attractive. Maybe we should leave it alone."

Janet sent the photo probe's data into the mapping programs. She watched the asteroid continue its rotation on the screen. Fearful, angry, fearful, angry.

"Not with Strieberists in upper management." Lindsey stood behind her, her hands on the back of Janet's chair. "Are you going to be able to concentrate on this?"

Janet tore her attention from the Gargoyle. Lindsey's question didn't make sense. "Excuse me?"

"Are you going to be sharp? Everything here has to be perfect. Our reports, perfect, when we send this to the company. There will be political ramifications if this turns out to be artificial. I can't have you mooning over the crew chief instead of doing your work."

"I am *not* thinking about that man!"

Lindsey shrugged. "So you say."

"I do say!" Janet's face flushed. She bent over the keyboard, tapping the instructions that would separate the sampler probe from the mapper and send it to the surface.

Janet jogged up the ship's long curve, enjoying the track's yielding surface as it cushioned her bare feet. Behind her, footsteps approached, so she moved to the side, her shoulder nearly brushing the wall to her left until the runner passed. Here the ceiling was low, cutting off the view of the passage sixty meters ahead. She could never shake the feeling she was running uphill. At least, it appeared that way, a steady climb in front, and if she looked behind, a steady climb the other way. Running in the circular station was like perpetually hitting the bottom of a rounded valley. Across the broad sidewalk to her right, she passed doors, hallways and windows. The infirmary, a long section marked with red crosses at either end, rolled by for the third time. Once more would make a five-kilometer workout, her required aerobic ration.

Without the kiss, Alec wouldn't be a problem. It happened a week ago. He'd been reading an asteroid's assay numbers and a mathematical map that showed stress lines, faults, and probabilities of mass shifts once they began operations. The top sheet of papers on a pile near the edge of his desk slid off, fluttering to the floor. They'd both reached for it, her hand on his shoulder as they bent down, and when she looked up, he was there, an inch away. It must have been something in his eyes, or maybe she could feel his muscles tense under his shirt, or maybe it was just a short circuit in all her thinking processes, but she leaned the slightest bit, pressed her lips to his, and then the moment was gone. He bolted straight up, knocking the remaining papers into the air. She fell back, banging her elbow on the chair's edge, and as she grabbed the sore spot, she saw his expression, eyes wide in fear (or disgust?). He spluttered something incoherent, face red, then fled the room.

She blushed to think about it.

More footfalls behind her. She moved to the side again, slowing in thought. The maps showed the Gargoyle was an almost perfect sphere, varying no more than a few centimeters in diameter measured through the poles or the equator, another good argument it was artificial. Bodies this small didn't have enough gravity to pull them into round shapes. Most asteroids were rugged, irregular,

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nearly solid nickel-iron chunks, or jumbled carbonaceous chondrite rubble piles. The only way she could think to form a small, spherical body in space would be to heat the entire mass to a liquid state, and like a water drop floating in a no-gravity chamber, it would pull itself into a perfect globe. But the Gargoyle wasn't a smooth, spinning bowling ball; it was a designed object. Still, there was a blessing in the shape: figuring orbits around it would be easier. The last asteroid she'd sent a probe to was shaped like a four-kilometer long dog bone with an eccentric wobble, and the gravity going around the long end was three times that of circling the narrow middle. She'd used a lot of the probe's fuel keeping a consistent distance away from it while she mapped.

Alec spoke almost in her ear, "When I run toward the spin I feel faster."

Janet stumbled, then recovered her stride. She tried to speak, but what came out instead was a cross between a cough and an exclamation that sounded like "Gack!"

"It's a funny thing," he said, as if she'd made no sound at all. "I know it doesn't make a difference which direction I go, but when I jog into the spin, it's like the ship rotates beneath me. Going the other way is like trying to catch up, and my strides seem shorter." He had a pleasant speaking voice.

"Have you tried timing it?" she asked finally.

"Same time both ways. Doesn't change how it feels, though."

They ran side by side for a minute without speaking. Janet thought of a dozen things to say, but nothing sounded natural. She almost said, "How do you like cheesecake?" The thought made her smile. Margo would be pleased if she had. When another jogger approached, going the other direction, Alec dropped behind to let him pass. On his chest, the jogger wore the familiar green and white Strieberist button that read, "They are waiting."

The infirmary slid by again on her right. Janet stayed in her rhythm. Why was he talking to her? Had he come behind her on the track by coincidence, or did he want to be with her? Was he just a nice guy who talked to anyone? What was she supposed to read into this encounter?

And he had saved her life. Of course anyone might have noticed the flaw in her space suit before they'd gone on that mission, but he was the one who caught it. How could she date a man who'd saved her life? It was too corny. Knight in shining armor stuff. It put them on unequal footing.

She cleared her throat and said, "This makes me think of a hamster in an exercise wheel."

He didn't answer.

She said, "Where the wheel goes round and round, and the hamster works like crazy to go nowhere."

Without slowing, she glanced over her shoulder. He was gone. She sighed. Just as well. The probe would be near the Gargoyle now, and she wanted to be there when it touched down. It would take several hours to start sending back its analysis, but she felt more in control if she was in the lab while the probe worked.

For a while, the mapper tracked the sampler on its way, showing the tiny craft approaching the Gargoyle, puffing out compressed air to control the descent and to match the slowly revolving asteroid's spin, but the orbiting mapper would be on the other side when the sampler made contact. Sweat tickled Janet's forehead. Landing a probe on an asteroid was tricky business, even with automated routines and computer assistance. There was almost no gravity, so the asteroid didn't help orient the probe, and the probe's kinetic energy remained the same, so a percentage point miscalculation would slam it into the solid surface, and also, she'd chosen the angry face to land on. Now that the probe was

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within a few hundred meters, all the details were clear. There were lines in the expression, taut skin pulling away from its mouth, a tension in the cheek area, all in black and grey relief. The lifeless pupils seemed to track the probe in as it approached. Dark pocks scarred the surface, as if the face had been disease-ravaged. Watching the expression grow larger was unnerving.

"You're closing a little fast," said Lindsey.

"I've got to anchor the probe or it'll just bounce off. If you were standing on the surface there and twitched your toes, you might achieve escape velocity."

The face swelled until there were no discernable features, just the pocked skin. Then the probe's shadow, its spiderlike feet reaching closer and closer. Touchdown. Janet sent the signal to fire the anchor bolts in case they didn't deploy on their own. She took half a breath in relief. The probe continued. The feet broke through. Shards flew toward the camera, then nothing. No image.

Lindsey coughed. "That's expensive equipment. What happened?"

Telemetry came in fine. The machine's little nuclear heart still beat. Janet ran through a handful of tests. The internals looked green, but there was no video, and she couldn't tell what the probes' attitude was. "The face must have been a shell. If it's spikes underneath, the probe could be wedged between a couple. The arms are stuck. I can get the sampler to deploy, but it's not reaching anything. For all I can tell, it might be pointing straight up and be nowhere near the surface."

"Can you shake it loose? Take it up and bring it down again?"

Janet shrugged. "I can't tell which way we're facing. Without the video, I can't see, and with all the metal around it, radar orientation won't work. It could wedge in deeper. We'll have to wait for the mapper to come around so we can see it. I can bring it in close for a good look, but it won't be in position for several hours."

Later, after she'd made the adjustments in the mapper's orbit, she leaned back in her chair and watched numbers march down the screen. Lindsey had gone to a management meeting, leaving Janet alone in the cartography lab. She tapped her fingers on the table edge. Above the monitor hung the Gargoyle's two clearest images. Fearful and angry.

Was this first contact? The long-sought evidence that mankind wasn't alone in the Universe? She knew they were on the edge of something tremendous, but a voice kept creeping into her thoughts, coming from just behind her, not out of breath at all, saying, "When I run toward the spin, I feel faster." She wondered if Madame Curie thought about laundry while she was discovering radiation, or if Buzz Aldrin found himself contemplating a crabgrass problem in his lawn while the Eagle was going down. This would be so much easier if she just knew what he thought of her, but the messages were enigmatic. One day he ignored her, the next he went out of his way to say hello.

She shook her head and studied the mapper's data. Some measurements didn't make much sense. The Gargoyle's magnetic field was what she expected for a body of its size, but there was a ghost image underneath the main one, as if there were a second magnetic source within the asteroid. Deep radar imaging didn't help either, although there were four tiny bright spots on the surface: one on each face and at the poles. She programmed the mapper to take close-ups of one of the spots when it made its nearest pass.

The intercom crackled. "Hey, roomie. Cracked the mystery yet?"

Janet said, "Hi, Margo. Nope, and we've just a few hours before the Gargoyle will be at eyeball distance. Some Strieberist working outside's going to catch a glimpse, and we'll have a riot. And you know what's funny? They were right all along. The Gargoyle is alien. Lindsey is confabbing with the upper mucky-mucks about what it might be

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and what to do about it."

"What's your guess?"

"Maybe it has religious significance." Janet thought about the Sphinx and the pyramids, ancient structures from a long-gone civilization. It was hard to imagine why an advanced, technological society would build such an inaccessible shrine. "I lost the sampler probe. It's as if whoever designed it didn't *want* anyone to land on it. I don't know what the ship's going to do when we get there. We won't be able to anchor easily, and it's too big for a controlled melt. We could set up every mirror on board, and it would still take a hundred years to heat it enough."

"When administration says 'jump,' we're not supposed to ask why. Maybe their interest is scientific."

Janet laughed. "Not a chance. If it isn't profitable, they won't do it. They must figure the Gargoyle is a treasure chest."

"Why the faces?"

"To scare off the superstitious?"

On the monitor, video from the mapper streamed by as the asteroid grew in size. Closest approach would be in a few minutes. Janet shivered. No matter how she looked at it, the effect was creepy, like a hedgehog wearing a lizard mask. "Whoever made this was more advanced than us, and it was a tremendous effort. There's some practical purpose here."

"Could it be a tomb like for the pharaohs?"

Janet started at Margo's echoing her thought. "We're going to have to find out. Lindsey will insist on a complete investigation. I'll take the jalopy over for a personal touch. Standard procedure is to pull the ship within ten kilometers, but I'll bet we won't get closer than a hundred on this one. It'll be a long flight."

The mapper's monitor began spitting out images as it gradually swept past the asteroid. "Gotta go," Janet said and broke the connection. First, she looked for the probe. Underneath the face's left eye was a new, dark blemish. What sunlight there was dropped straight into the hole, and she could see the probe canted to one side. A tough angle, but now that she knew, she could get it out on its own power, assuming the jets weren't bent. She rubbed her chin, then directed the camera at what she'd thought were pock marks. They were all holes. They must be from smaller asteroids colliding with the Gargoyle. How long had it been tucked into this orbit? Why weren't there any large meteor strikes? Every asteroid they'd surveyed showed a long, violent past, filled with collisions, but other than these small holes, the Gargoyle was unmarked. She wondered if Texas-sized Ceres, which led the Gargoyle in its long route around the Sun, absorbed most of the rocks that should have pummeled the smaller body.

The mapper continued across the surface until it was over a shiny spot the radar had picked up. An image assembled itself on her screen. She enhanced it, then sat back, shaking her head. It was a couple of meters wide by a meter high and appeared to be made from polished rock or metal. Even with the monitor's fuzzy resolution she could see illustrations and writing. She contacted Lindsey to tell her the Gargoyle had a plaque.

The jalopy was an awkward-looking rhomboid assembly of tubes, compressed air jets for propulsion and maneuvering, and several tool chests loaded with prospecting and mapping equipment. Inserted in the middle were two lightly shielded pods for the pilot and passenger. Alec and an equipment handler were already in the launch bay checking the supplies when Janet walked in.

Alec said, "This doesn't look like a mining operation to me. They ought to be sending an archaeologist." He scowled as he inventoried a locker and then slapped it shut.

"Probably," said Janet, raising her eyebrows. Rather than risk upsetting him more, she moved to where her suit was stored. What's wrong with him? she wondered. Soon, though, she was into

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the rhythm of getting ready for the mission. Every new asteroid required an initial human survey. There were too many variables in hooking the mining operation up to rely on robot reports. Asteroid composition could vary from one spot to another. A seemingly solid rock could be deeply cracked, or might be a dozen loosely-melded pieces. Many turned out not to be suitable for easy mining. Too many silicates, not enough clean ore, not a clear site to base operations. For every five or six asteroids they visited, the ship would pause at one, but tons of usable metal could then be extracted, milled, smelted and shaped, then sent on the long, elliptical path that ended in lunar orbit for assembly into the ark ships. At the same time, chemical processes produced fuels and other usable products. Mining the asteroids reminded her of the Eskimos who used every part of a slaughtered sea lion.

Janet and Alec had worked as a team for three years. It was possible to do the whole job without talking, but they never had. She worked her way into her suit. Next to her, Alec pushed his arms into the thick, clumsy sleeves, his face just as dark and angry as it had been when she walked in.

"Ready," he said a few minutes later. Janet nodded. An assistant hooked her onto the hoist that lifted her over the jalopy and into her pod. Soon they were alone in the launch bay as the engineers left, closing the airlock doors behind them. Her suit stiffened as the chamber was evacuated, then the launch doors opened beneath them. The ship's spin provided the initial velocity. All that was necessary was to orient the ship and time their release, work that didn't need their input. Although launching was routine, it was a team effort, with dozens of others making the trip as smooth and safe as possible.

Janet triggered a private communication line as soon as the vacuum was established.

"What's wrong with Alec?" she asked.

Margo answered. "I thought you'd never get back to me. I've got his med readouts. Elevated pulse and respiration. He's scared. Xenophobia."

Alec's shadow moved in his pod's translucent shell as he checked the instrumentation. Beneath them, the stars scrolled past. "What's our transit time?" he asked.

Janet flipped to his frequency. "Twenty minutes. They pulled us closer than I thought they would." She clicked back to Margo. "Scared? I thought he was mad. You should have seen his expression." Her finger rested on the manual releases as she watched the launch countdown. She'd press her button at the correct time as a backup to the computer. "If he's that bothered, should he be going? I can't have him making judgement errors."

"He's not *that* scared. Check your own readouts."

Above her head, among a plethora of information, were her numbers, all elevated.

The countdown reached zero, and Janet pressed the button, dropping the jalopy from the mining vessel. Her stomach did the familiar lurch from the 1G environment to weightlessness. She rotated her pod so she faced their target, almost invisible in the fathomless black. During the trip, she stayed busy directing the craft to the Gargoyle's surface. In the few jobless moments she had to contemplate their mission, she listened to space's sound, which wasn't silent at all. Her suit hummed and whirred. Air hissed in the helmet's close confines. Behind it, her pulse throbbed. From the unmarked distance, the Gargoyle appeared, grew large, and soon filled the sky.

To anchor, she chose a spot in the spike field to the angry face's side. Unlike the probe, it wasn't her intention to fire explosive bolts into the surface. Instead, she would allow the craft to settle onto the spikes. Up close, they didn't appear as regular as they had in the vids. Micrometeor strikes had scarred them.

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Some were broken or cracked. Others bore smaller blemishes, like bullet holes. The distant Sun's light through the spike forest cast awkward, impenetrable shadows, hiding the base structures.

The jalopy glided a few meters over the spikes until the edge of the angry face appeared on the horizon. Janet slowed the exploration craft until the spikes beneath them matched their speed. They descended onto two blunt tips, and the ship canted to rest on the shattered end of a third.

"We're here," she said. Not a quote for the history books, she thought.

Alec let loose a long, relieved breath. "You wouldn't believe what I've been thinking."

Janet powered the jalopy down, unbuckled herself, hooked a safety line to her belt, and pushed herself from the pod. "Try me."

"It's so obviously artificial. I thought it would open fire. I'm a little jumpy."

"It's dead, Alec." Janet laughed to herself. Odd thoughts had crossed her mind too.

Alec hooked himself in and floated to a tool locker in the Gargoyle's minuscule gravity where he equipped himself with a specimen hammer and sample sacks. "I'll get pieces from these spike tops, then move down to the base."

Janet nodded, then remembered to say, "Yes," as she jetted toward the face's edge, twenty meters away. From this angle she could see it was a thin plate resting on the spikes. She braced herself between two stone spears to examine the material. A hand's-width in thickness, it didn't appear to be either stone or metal. More like black porcelain than anything else. She smacked the top with her hand, but the leverage was bad, and all she succeeded in doing was losing her grip. For a second she floated, unanchored, then she grabbed the edge again, this time to hoist herself to the surface. At this angle, she couldn't tell it was a face. Every few meters, a hole marked the smooth surface, and her light revealed the spikes below. She glanced back to see Alec stuffing something into a sample sack. He waved, then attached his safety rope to a different spot. His voice crackled in her radio. "Looks like typical nickel-iron to me, a dark deposit on top, lighter underneath."

"So they made it from an asteroid."

"Would appear so."

"OK. I'm going to the forehead to check out the plaque."

Alec grunted, a preoccupied sound. He chipped a bit from one spot, played out the slender safety cable, then glided to the next.

The Gargoyle's gravity was negligible. If she dropped a hammer, it would take minutes to complete its fall, so she drove an anchor bolt into a spike, attached her original line to it so there was now a path from the jalopy to the face's edge. When she reached the plaque, she'd place another bolt. Some asteroids had so many safety lines running across them, they looked like they'd been netted.

A gentle push from her back unit slid her across the Gargoyle's face, past its twisted mouth filled with spiky teeth, past the deep gashes that were its nose, across an eye's smooth bulge, to a knee-high platform on the forehead's edge.

"I'm moving toward the surface," said Alec. His breathing sounded regular, his voice clipped. Janet guessed if she could take his pulse now, it would be normal, while her own heart pounded in her ears. This was an alien artifact, concrete proof there were other sentient beings in the Universe. She twisted her hand control to emit gas in a tiny puff that slowed her.

It was a plaque, just as the probes' flyby had shown, packed with symbols, illustrations, and hieroglyphics. The largest illustration dominated the plaque's middle: at the top, a diagram of the Gargoyle. Next, a cutaway view showing the asteroid's interior with an odd symbol at the center. She thought about the funny magnetic readings. Was it a storage chamber? Then, a larger circle around the Gargoyle without the cutaway view. A planet? An

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orbit? The last illustration showed the circle fragmented into broken lines and a series of intersecting lines where the Gargoyle had been. An explosion? She clicked pictures from several angles, then crouched to see how it was fastened onto the platform.

Her gaze was on the horizon.

A screech in her helmet.

Alec shot up from the asteroid's surface, maneuvering jets on full, pushing him away from the asteroid. The safety cable, which was anchored sixty meters from him, snapped taut, pulling him into a parabola. First up, then parallel to the surface, then just as quickly, straight down. He disappeared into the spike field. Too fast.

"Alec?" she transmitted. She'd already detached her safety line, pushed hard away from the plaque toward where he'd gone in, and without thinking, made the corrections that killed a spin she'd picked up. She slapped the emergency "come hither" button, sending an automatic call for help, while flipping through displays until she found his suit telemetry. Pulse, fine. Breathing, fine. Air pressure, fine. She took a few deep breaths of her own. Suit temperature, fine, but falling. Partial system failure.

Questions from the ship. Nothing they could do now. She shut communications down. Concentrated on maneuvering. If she overshot, she'd waste too much time slowing, reversing direction, accelerating, then slowing again. A man in an unheated suit in shadow would freeze. She tried to remember how much time he might have. Couldn't come up with it. Too long since the refresher course. Most suit accidents were instantly fatal.

It wasn't until she paused over the spikes where he'd vanished, that she wondered what had thrown him off the surface in the first place. She directed a light down. His lower torso was visible, feet up, the rest was caught between two spikes as thick as tree trunks. No movement.

He'd yelled, a frightened yip. And his jets had been on, so he hadn't been tossed up, he'd jumped and then blasted. What scared him?

His safety cable pulled at the suit's side, as tight as a piano wire. She unsnapped it carefully, keeping her hand and head clear as it whipped from sight. Working by her helmet light, she inspected the damage. Alec's momentum had jammed him into the space between two spikes. The cover to the power unit on his back was cracked and bent. Whatever was broken inside, she wouldn't be able to repair it from here. The quicker she could extricate him and get him back to the ship, the better. She pulled herself around so she could look into his faceplate. In the middle was a blood spot matching a welt on his forehead. His eyes were partially open, with white slivers showing. He didn't react to the light in his face or to shaking.

The asteroid's surface, where the spikes were anchored, was a couple meters below them, but too far for her to push him. She tried bracing her feet on the spikes' steep sides, but there wasn't enough grip and her feet slipped on every effort. Her breathing sounded harsh in her ears. "Damn it, Alec." She rested for a second, her head down.

This deep in the spike forest, the Sun didn't penetrate. For the first time, she looked around her. Black, heavy columns leaning every way, marked by shadows that barely showed on their charcoal-like surfaces.

She scanned part way around before she saw it.

A scream stuck in her throat. By reflex, her legs pushed. If she'd been touching, she too would have flown straight up, but she'd drifted just enough that she kicked against nothing.

It was an alien figure, face like the one on the surface, peering around a spike, angry as hell, arms raised, claws extended.

By the time she'd scrambled to the other side of the columns that held Alec, she realized it couldn't be alive, but it

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took a long minute for her to approach, heart thudding, mouth dry.

The alien was a statue made from the same material as the asteroid. Its skin was polished, details sharp, like finely worked obsidian, her height, heavy in the chest, a short, hairless tail. Beyond it, others crouched behind spikes; some charged, carved in attack. Their frightening forms filled the forest. Janet guessed there was more statuary on the reverse side, mirroring the fright of that face. Angry or frightened. Nothing in between. She took pictures by habit.

Putting the camera away, she pushed herself above the spikes, then jetted to the jalopy. If she could free Alec, she could plug his suit into the exploration craft's power system and get around the break in his own.

It took a few frantic minutes to unanchor and lift off. She tried to eyeball where he was, then realized she hadn't marked the spot. The spikes' tops all looked the same, uniform in their randomness. She started the jalopy forward in the general direction while she tracked down his suit's signal. Soon she was above him. With the jalopy anchored again, she fastened a cable to the sturdy frame, then dove down where he was still stuck and unmoving. Not looking at the statue reaching toward her took willpower. Getting Alec off the asteroid was a solvable problem, immediate, without the ambiguity of the message the statues sent. Were they alien gods, represented in stone? Were they art? Were they important at all? It didn't matter now. She fastened the cable to Alec's suit, then measured several meters of slack. Using the jalopy to pull him out by a straight pull wouldn't work. The compressed air jets didn't generate enough thrust. She'd need to use the jalopy's weight and momentum to jerk him out. She played out more cable, cinched it, then headed up.

The jalopy moved away from the spikes. Janet watched her speed and orientation so she didn't drift. It had to be a vertical lift off or she risked pulling the unconscious man across the spikes instead of up. Acceleration was slow. Return trips always took longer than going out.

One meter, two, three, four. How much cable had she left? Five, six. A gentle jolt shook the jalopy. Slowly, Alec rose from the spikes. Janet hit the autoroutines to get them back to the mining ship, then reeled him in. Soon he sat in his pod, plugged into the jalopy's power. His suit temperature rose. She stayed beside him, directing her light at this faceplate, waiting for the frost inside his helmet to melt.

He coughed, a sudden sound in her radio. His eyes opened, then squeezed back shut.

"How do you feel?" she asked. Her hands shook a little. Post emergency shock, she thought. Margo would explain it to her later.

"I saw a monster," he said thickly. He closed his eyes, and lolled his head against the helmet's side.

Medics hustled Alec away from the dock, and Janet had just removed her suit when she was summoned to Lindsey London's office. Lindsey waited inside, a tissue in hand and wearing a pained expression. Behind her were two upper-management types she barely recognized. One, an older man whose hair had gone pure silver around his ears, mirrored Lindsey's discomfort, though Janet doubted a sinus infection caused his; the other, wearing a Strieberist button, smiled widely.

"Oh, you are so lucky," he said, "to be the first person to land on an alien artifact. Let me shake your hand." He squeezed hard, and for a second Janet thought he was going to hug her too. "Your life is in for a change. When the media gets hold of this, you'll be the most famous person in the solar system."

"We can't jump to conclusions," said the older one. "It may not be alien."

Janet looked at him in disbelief.

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Lindsey said, "I did a calculation based on meteor strike frequency on its surface. The Gargoyle's been in space at least three million years." She blew her nose. "Give or take a million."

"Even if it is . . . extraterrestrial, whoever left it certainly isn't around now," said silver hair. "This find shouldn't impact our basic mission. We'll leave it to scientists who are better equipped."

The Strieberist shook his head. "No, no, no. Don't you understand that this removes the need for our mission? The aliens left this for us to discover. It's their invitation to us. What else could it be? We should find out where the Gargoyle came from, and then bend our efforts to contacting them. It's mankind's most heroic quest yet."

"That's a *scientific* question. We are a *business* operation," said silver hair. "We have neither the expertise to investigate the artifact nor the authority to abandon our mining efforts."

"What are you talking about? Investigating? I've never seen a more uninviting spot in my life." Janet looked from one to the other. "Did you see the pictures of the statues on the surface? Have you looked at the plaque?"

Silver hair cleared his throat. "There's some argument about what the plaque means. There appear to be several kinds of writing and diagrams. Our analysts compared it to the messages we attached to our deep space probes early in the space program."

"Which we included to introduce ourselves to other intelligences." The Strieberist sat on the edge of Lindsey's desk. "I agree with that analogy."

Lindsey called up the plaque on the wall monitor. "You saw it close, Janet. What were your impressions?"

"I didn't get to look at it long." She moved to where she could study it closer. The marks made no sense. She thought there would be little chance she could decipher the plaque's intent if it was written in Chinese, and that was a heck of a lot closer culturally to her than this communiqué. "The only thing I recognize is the diagram in the middle, with the Gargoyle, but I don't think we need the plaque to understand the big message, which is to stay away. I've never seen a clearer no-trespassing sign in my life."

The Strieberist bristled. "There is a message here, and it's a welcoming one to an *intelligent* race. The expressions might represent their smiles. Our evolution is obviously different. What makes you think we could recognize facial expressions in whatever they descended from? When we decipher the plaques, you'll see. There will be formulas for super-science. Maybe faster-than-light technology, or bio-breakthroughs that will revolutionize human life. See there?" He pointed to the cutaway diagram of the Gargoyle. "They've buried something for us. Why else would they show the asteroid's interior unless they wanted us to get it?"

Janet thought about perceptual set. The Strieberist saw what he expected to see. "In New Mexico there's a radioactive waste dump in the salt deposits. When the government chose the site, they had two worries: one, how to keep the waste from leaking out, and two, how to keep people, generations down the road, maybe long after any record of what was buried there had been lost, from digging it up. The problem was any monument they left could be misinterpreted. It's like the pharaohs' tombs. They were all looted. You can't trust that anything left over great stretches of time won't eventually be disturbed."

She pointed to the diagram. "You know what I think that is? Something deadly. The circle around it in the next diagram is the Sun. The last diagram shows the Sun exploding. Maybe they had a war and made a sun killer that couldn't be destroyed. Maybe it's their toxic waste. The faces are angry and fearful. Maybe those emotions and expressions are universal. Run away and be afraid."

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Lindsey nodded. "If there is something in the Gargoyle, we'd want to study it much longer before opening it up. I'm including a recommendation in my report to quarantine the site."

"That will be my suggestion too," said silver hair.

The Strieberist slapped the desk. "My people won't put up with this. We have a right to know what is inside this artifact."

Janet looked from Lindsey to the older man to the Strieberist. It was a political struggle, and they weren't going to listen to her now. Whatever happened, it might take years to resolve. She remembered the statues at the surface, how they scowled and grimaced, how their hands were poised to rend, and she shivered. If they believed her theory, there was no way they could ever know what was inside the asteroid. She thought about Pandora and Bluebeard's wives.

"I would like to go check on Alec," she said.

Lindsey nodded, then turned back to the argument. As Janet left, they were shouting at each other.

Thick bandages wrapped Alec's hands, and a slimy ointment had been smeared on his ears and nose.

"It's frostbite," Alec said. "Another ten minutes, the doctor tells me, and I'd have been frozen to the core."

Janet pulled a chair next to him, not sure what to say.

"They showed me your pictures from the Gargoyle. It was a statue I saw, wasn't it?" His face reddened slightly.

"Anyone might have reacted the same way, Alec. I'm just glad I was there to get you back." She put her hand on his arm.

"You saved my life. That's a pretty big deal."

She shrugged. "It just makes us even."

He leaned back and closed his eyes. "What are they saying about it?"

"I think they're going to haggle for a while, and then somebody will open it up."

Alec shook his head. "If I put one of those statues in the conference room, it would change a few minds. We need to do something to stop them."

"Some day we can, but not today. Today you need to get better. There'll be a lot of arguing among folk with a bunch more pull than we have before anyone makes a decision." Janet was already imagining the report she would turn in. If the Strieberist was right, she and Alec were famous now, the first humans to land on an alien artifact. Their voices might be louder than they would be otherwise. She smiled. There was reason to hope.

A technician wheeled in a cart with a food tray. "Time to eat," he said. "We got you stuff from the cafeteria. No dietary restrictions for you, so dig in." He put the tray across Alec's lap before he left.

For a minute Alec looked at the meal, then at his wrapped hands. He laughed. "I can't hold anything. I don't suppose you could feed me?"

Janet reached across Alec to pick up the fork. On the tray was meatloaf, corn, a roll and a piece of cheesecake.

He kept his eyes on hers through each bite, and he never tried to move the arm she held. His face fascinated her, how his mouth worked, how he swallowed. Once she wiped his chin and he nodded his thanks.

When she got to the dessert, she cut a fork full off and held it out for him.

He shook his head. "Too big," he said. "Cheesecake has to be eaten in small bites."

Janet smiled. Maybe she was seeing what she wanted to see. Maybe this was her perceptual set, but she didn't think so.

It was all she could do not to say, "You know what this means, don't you? We're not alone."

She trimmed the piece and fed it to him delicately. ■

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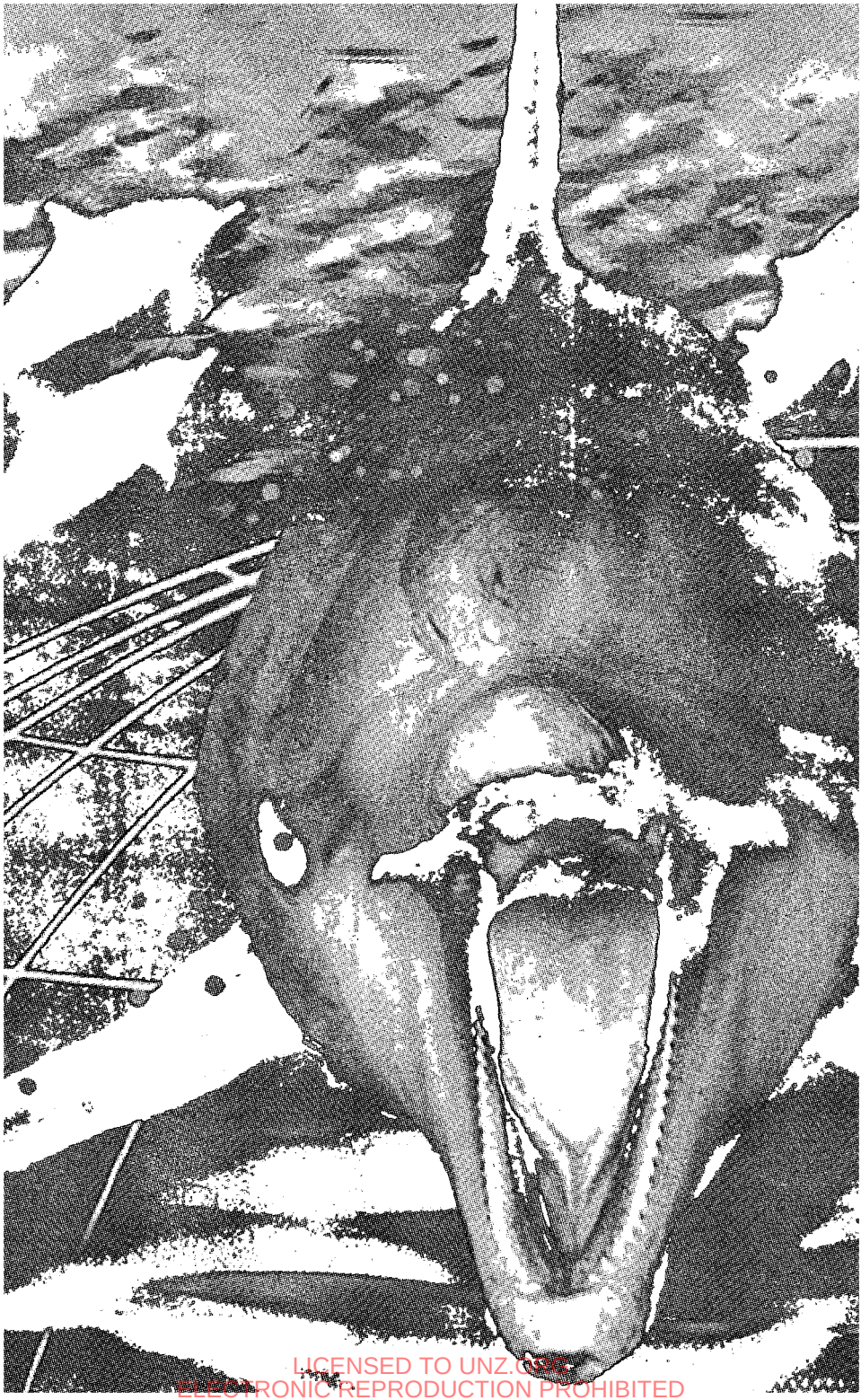

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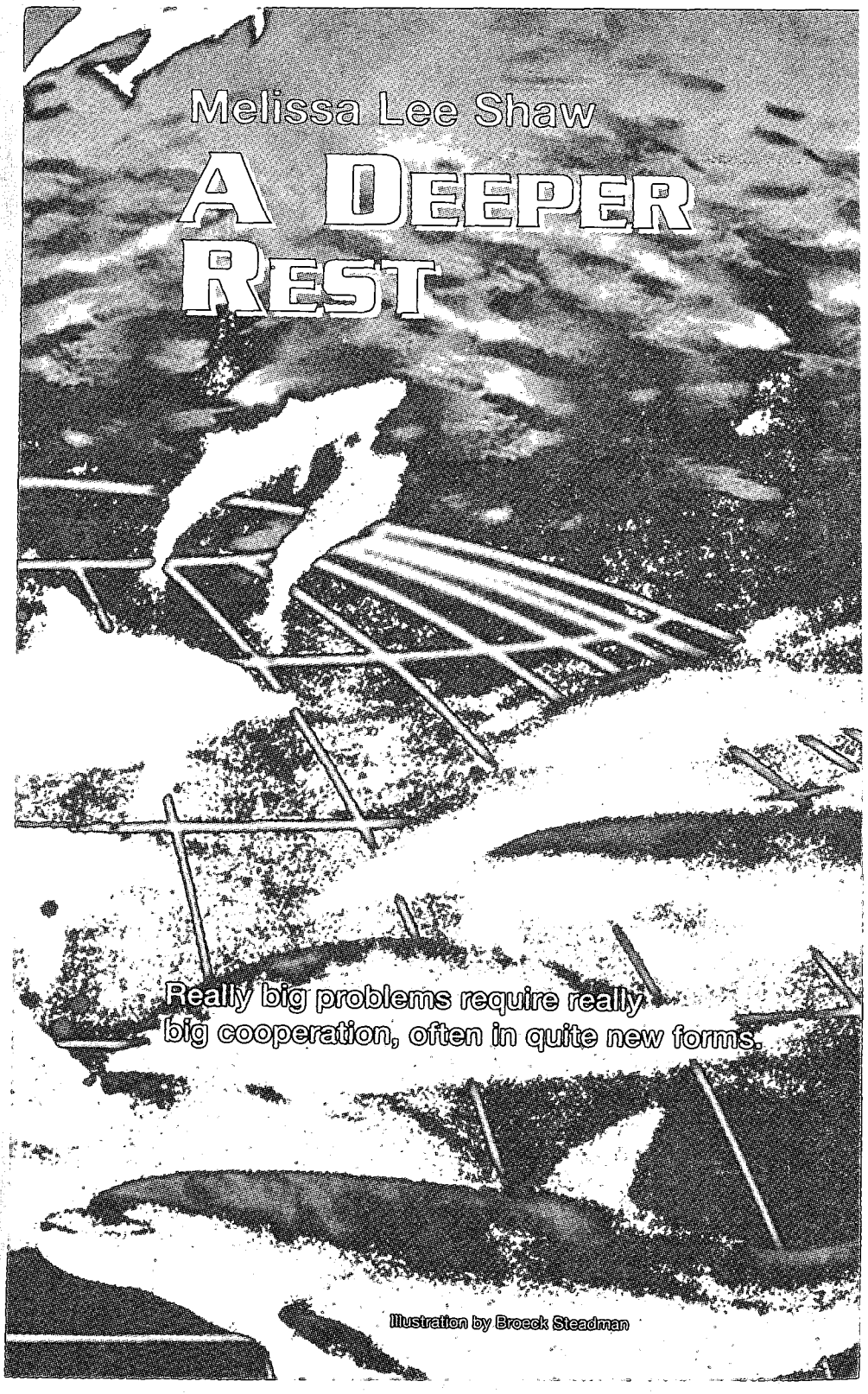
Melissa Lee Shaw
A Deeper Rest
Really big problems require really big cooperation, often in quite new forms.
Illustration by Broeck Steadman

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A hundred feet from Waikiki beach, a snorkeler floated, enjoying the hot Sun and the warm, clear water. When he lifted his head to get his bearings, his heart clenched.

A gray dorsal fin was headed toward him.

A second look showed the fin to be recurved, not triangular—dolphin, not shark. His breath hissed out in relief.

The fin disappeared.

"Hey, uh, Flipper," he called, with growing excitement. "Flipper, come on back! I swear I only eat dolphin-safe tuna."

A sharp pain stung the snorkeler's left leg. He flinched and ducked his head underwater. Parallel scratches from knee to ankle leaked clouds of blood into the water.

Four more gray fins approached—triangular this time, not recurved. Panic drove the snorkeler toward the shore faster than he'd thought possible.

It wasn't fast enough.

Dulcie Huber slid into the tank's cold water, gasping and swearing at the chill. Her yelps elicited excited squeals from the two dolphins that crowded near her. A sharp-faced, gray-eyed woman in her early forties, Dulcie had a swimmer's body and a short brush of mahogany hair sprinkled with silver.

Misty, a nine-foot-long Atlantic bottlenosed dolphin, floated a few feet from a shallow platform with a bench just underwater. She kept one soft brown eye fixed on Dulcie.

"Well, hey there, sweet thing," Dulcie said. She sat on the bench, bracing her feet on the platform below. The water slopped around her stomach. "Come on over here." She held her arms in a circle.

With a flick of her tail, Misty shot onto Dulcie's lap. The water supported most of her four hundred pounds. Over the years, Dulcie's legs had grown strong supporting the rest. Dulcie hugged the dolphin, laying her head on the sleek gray side. Misty buzzed softly, a cross between a Geiger counter and a purr.

Sport, Misty's six-year-old son, whistled inquisitively a few times, then squawked.

"In a minute, you big tuna." Dulcie held up her hand in a WAIT signal. "It's not your turn yet."

Sport squawked again, then zoomed over to the huge keyboard suspended underwater against the tank wall. He stabbed the buttons with his rostrum, lighting them up. "REQUEST DULCIE HUG SPORT."

"Hey, Ian?" Dulcie called.

Her research manager, a young man with curly, unkempt red hair and a trim goatee, appeared in the doorway to the offices. "Yeah, Dulcie?"

"Would you please go tell Sport he has to wait; maybe give him a toy?"

Ian went over to the keyboard's smaller twin, which sat just beside the tank under a Plexiglas shield. He punched in, "DULCIE HUG MISTY NOW. SPORT WAIT. DULCIE HUG SPORT LATER."

Sport squawked and hit the "NO" button.

Ian hit, "YES. FINAL ANSWER. SPORT WANT BALL?"

The dolphin floated for a moment, then stabbed the "YES" button.

Ian tossed in a ball. A moment later, he ducked as Sport whipped it back at his head. The young dolphin sank to the bottom of the tank, sulking.

Ian chuckled. "You little snot."

The radio, which had been playing music, changed to a news report.

Dulcie frowned. "Turn that up, would you? I think I heard them mentioning whales."

". . . attacks have been growing more frequent," droned the radio. "Research biologists are trying to identify the elusive disease they believe to be causing the abnormally aggressive behavior. Current theory suggests that whales and dolphins have contracted a virus similar to rabies, which affects the central nervous system. . . ."

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"You missed the one earlier, on TV," Ian said. "The Coast Guard reported an attack on those Indian whaling canoes—what were they called, that tribe in the Pacific Northwest?"

"The Makahs."

"Yeah, the Makahs. Apparently a bunch of whales capsized the canoes and rammed all the nearby boats."

Dulcie snorted. "Poetic justice."

"This isn't a joke. People were killed—not just the whalers, but some Coast Guard and Greenpeace guys, too. And it's not just whaling boats—sailboats, fishing boats, even those huge ocean liners—they're all getting attacked. Hundreds of millions of dollars in damage in the past few weeks."

Dulcie leaned down and kissed Misty's smooth gray forehead. The dolphin's eyes were almost closed. "Dolphin rabies," she whispered. "At least you're safe."

"Kinda makes you glad we're so far from the ocean, huh?" Ian said, coming over to tankside. "Those aquaria with sea-pens, a lot of their animals have been contaminated."

For the past few weeks, an unspoken ban on moving cetaceans between facilities had effectively quarantined the animals. Online trade journals and newsletters were filled with articles and reports by emergency subcommittees. So far, nobody had pinpointed what the disease was, much less how it spread. Antibiotics had no discernible effect. Physical exams were nearly impossible to conduct without jeopardizing the handlers' safety, but the few that had been completed showed no abnormalities—no parasites, known viruses or bacterial infections, nothing to account for the new aggression.

Several necropsies had been performed on pods of stranded dolphins and porpoises. They revealed slightly increased levels of parasites and heavy metals, but no evidence of viral infections in the central nervous system, like rabies would produce.

It was so strange, Dulcie thought, that when one whale beached itself, its whole pod typically followed. Nobody really knew why. Was it a show of support? Blind obedience? Fear of being left behind?

"Hey, those Navy guys are coming in today, right?"

Dulcie glanced up at the clock. It was almost seven-thirty. "In about two hours. We all set for the demo?"

"Yep, everyone's prepped. You know what they want?"

"Probably to see results from the increased funding they just gave us last month. They're such patient people." Actually, she was grateful for the generous new research grants. They couldn't have come at a better time. Keeping dolphins was expensive; building state-of-the-art equipment for research was practically a dream, though it was closer to a reality now than at any time in the Cetacean Cognitive Research Institute's past.

The Navy had recently provided a much-needed influx of funds to her lab and to facilities in Florida and Hawaii doing animal language research, with directives to focus on two-way communication, like the keyboard. Dulcie was thrilled; most cognitive research involved giving the animals instructions in a controlled setting and measuring their ability to learn. Two-way communication, while fascinating, was far more difficult to control, quantify, or measure, and thus almost impossible to get grants for.

Sport finally surfaced, halfway across the tank. He cocked an eye at Dulcie.

Dulcie laughed. She patted Misty and slid her off her lap. "Sorry, hon. It really is his turn."

Half an hour before the Navy visitors were supposed to arrive, Dulcie sat at her desk, hair slicked back from her shower, scrolling through the July 2013 issue of the *Journal of Biological Frontiers*, which Rachel Schwartz, a fellow researcher, had sent her from a facility in Southern California. Rachel had book-

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marked an article about increased numbers of stranded whales and dolphins in recent months, a disturbing trend. Apparently there was a resurgence in *Morbillivirus*. A lot of the necropsies reported brain lesions consistent with the viral outbreaks that had compromised the immune systems of a lot of sea mammal populations back in the early 1990s. Sobering thought.

The phone rang. Skimming the table of contents, Dulcie picked it up. "CCRI, Dr. Huber speaking."

"Dulcie? It's Rachel."

"Hey, I'm just looking through the JBF you sent me. Pretty scary stuff, all those strandings."

There was a silence on the other end, punctuated by a sniff.

"Rachel, you OK?"

"I—well, no, not really."

"What happened? What's going on?"

"It's Tursi. He—Dulcie, he's dead."

Dulcie sat very still. Her ears felt fogged with cotton. "What?" she whispered.

"Bob found him, maybe an hour ago, when he got in." The words came in a rush. "Susu and India were holding him up in the tank, like he was a sick calf. . . ." Rachel's voice rasped and broke. "We tried artificial respiration, but it was way too late. He must have—passed—during the night, when nobody was here."

"Rachel, I'm so sorry. That's awful. Any idea why?"

"Not yet. Necropsy is scheduled for tomorrow. Dulcie, he wasn't even that old, only about twenty. And he'd been maybe a little sluggish for a couple of weeks, but nothing really unusual. I just—I know it's weird, but I thought of Sport, just in case this is some kind of genetic thing. Maybe you should keep an extra close eye on him."

"I will," Dulcie said, scribbling a note to remind herself to call the vet. "Jesus, I'm sorry. I don't know what to say." For a moment, she wondered if Tursi's death could have had something to do with the dolphin rabies scare, but she dismissed the idea, knowing he'd had no contact with the ocean for over a decade.

Dulcie could hear Rachel crying in the background. "Dulcie, I gotta go, I just—"

"I understand. Call me later if you want to talk."

As she hung up, Dulcie could hardly feel the phone in her hand. She rubbed her eyes, trying to focus. It was always jarring when a dolphin died unexpectedly, and this was one she had worked with while he was at CCRI for the breeding program exchange. Captive dolphins didn't die often without warning, but there was still a lot even experienced keepers didn't know about cetacean health.

Hoping to distract herself, she turned her attention back to the online journal. With the Navy demo only a few minutes away, she couldn't afford to fall apart.

An article caught her eye: "Genetic Engineering: Benefits and Risks." She skimmed the abstract with interest. The past ten years had shown a sharp increase in the number of people with digestive disorders. They mostly had food allergies and intolerances like celiac disease—an intolerance for wheat, barley, and other gluten-containing grains. Genetic engineers had attacked the problem with unprecedented success, creating a cheap and hardy strain of wheat with a symbiotic bacterium that acted as a pesticide. The bacterium also produced enzymes both to make wheat gluten more digestible and to enhance digestive tract function by relaxing muscles often abnormally tense in these stressful modern times. Bg wheat, named for Dr. Thomas Granieri and the *Bacillus granieri* bacterium that lived in symbiosis with the grain, had taken the market by storm. Its built-in safeguards meant that neither the wheat nor the bacterium could survive without the other.

Despite herself, Dulcie smiled; for years, she'd been unable to eat wheat products herself. While she'd been cau-

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tious at first about this new Bg wheat, she was grateful for it now. Rice-flour breads and waffles were no substitute for their gluten-containing counterparts. And because Bg wheat was cheaper and hardier than traditional strains, farmers loved it as much as she did, making it easy to find in stores. Some restaurants boasted that they now used Bg wheat exclusively.

She read on. Not all genetic engineering was so successful. Bt corn, a pest-resistant strain created in the 1990s, had probably contributed to—

—to the extinction of monarch butterflies.

"They're gone?" she whispered, shocked. When she'd been a kid, her family used to spend summers on a dairy farm in upstate New York. Pastures had been choked with milkweed, and monarch butterflies had filled the air with black and orange.

But farmers had destroyed the milkweed on which monarch butterfly larvae fed, to make room for crops. Bt corn, an increasingly common strain of genetically engineered corn that now filled over half the cornfields worldwide, was created in the mid-1990s. A pesticidal gene spliced into the corn from *Bacillus thuringiensis* bacteria interfered with the larval development of corn borers, insects that infected and destroyed entire crops. Unfortunately, the Bt corn pollen also drifted into milkweed fields, killing monarch butterfly caterpillars—or so claimed some environmental scientists, though biotech scientists argued that the lab studies didn't reflect field conditions, that almost all the pollen would be blown or washed off the milkweed plants, that new Bt corn strains were safe. The debate raged through the early 2000's, each side contesting the other side's findings.

None of which had helped the monarch butterflies.

Dulcie wondered if this was how early Americans had felt on learning that the last passenger pigeon had died, after seeing the skies filled with them. Such pretty things monarchs were—had been. Once common as horseflies, now gone forever. It seemed unthinkable. Grief welled up again, cold and sharp.

"Dulcie? They're here. Hey, you OK?"

She took a deep breath and closed the journal's window on her computer. "I'm fine, Ian. I'll be right out."

The demo went smoothly at first; Dulcie ran the eight lab dolphins through their paces, starting with flashy tricks like jumps and behavior mimicry, and moving up to more complex, language-oriented tasks.

The Navy officer—Rear Admiral William Pangborn—seemed impatient, or maybe just tense, though he hardly stirred in his rigid stance. A tall, solid man with gray-streaked dark hair and hard, cool eyes, he made Dulcie nervous. As the lab staff were setting up for another part of the demo, Pangborn turned to Dulcie and said, "Doctor Huber, what we're really interested in is the keyboard research, the two-way communication of abstract and complex messages. I'd like to move along to that, if you don't mind."

She suppressed a surge of irritation. "We'll be getting to that soon. I just want you to see that your funding is being spent well. We've accomplished a great deal in a number of areas in the past several years, including studies of sonar, behavior modeling and mimicry, cognitive mapping—"

"Doctor Huber. We are on a very tight timetable here. I have no doubt you have accomplished remarkable things, but what I am interested in is the keyboard research."

"All right, Admiral. Just give us a few minutes to set up. Excuse me, please." Fuming, she went to Ian and explained in a low voice that they were going to scrap everything except the keyboard stuff.

"You want to use Boomer?"

"No, Misty. I know Boomer has used

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the keyboard more recently, but he's not really picking it up that well. Misty knows it cold. Let's gate all the other dolphins into the other tanks, except Sport."

Ian bustled away, calling cheerfully to the volunteers, student interns, and paid staff. Before long, Misty and Sport were gated into the tank with the keyboard. Extra trainers entertained the other dolphins.

Dulcie returned to the Navy visitors. Admiral Pangborn was conferring in low tones with Lieutenant Jeremy Fox, a marine mammal veterinarian from the Naval Ocean Systems Center in Hawaii. Fox was tall and lean, with animated brown eyes and dark hair that curled despite its short cut. Three lower-ranked Navy staff stood behind the two officers, watching the dolphins with interest.

"All set, sir. If you'll follow me." She led them to the small keyboard at tankside. A Plexiglas booth protected them from splashes. "The keyboard is one of our most exciting interactive tools—we try to use it as much as possible, to encourage the dolphins to think and communicate in a languagelike way. There's a large keyboard in each tank, and a corresponding smaller one on our side by a window. We have worked to reduce the importance of food rewards, to vary the reinforcement we use. A number of the buttons on the keyboard can be combined with the REQUEST key to ask for things like toys, games, and human interaction. Each button lights up and has a unique computer-generated sound, so the dolphins get both visual and acoustic feedback."

The keyboard had eight columns and ten rows of buttons, divided into a top and bottom section with five rows each, for a total of eighty buttons.

Dulcie pointed at groups of buttons, color-coded on the small-scale model used by the researchers. "We have buttons for objects, like ball, basket, rope toy, and others for actions, like whistle, jump, touch, and bring. There's a button indicating each trainer specifically, another for generic 'person,' and a third for 'all people,' meaning everyone either in the tank or touching the water. There are also individual buttons for each dolphin, another for generic 'dolphin,' and a third for 'all dolphins.' So for example, we can ask Misty to touch any person with her pectoral fin—" she nodded to Ian.

"People in," he called, and four staff put their arms in the water, spaced at intervals around the tank. He hit "MISTY PEC-TOUCH PERSON." Misty zoomed across the tank, lifted her pectoral fin, and touched an intern's arm. Ian blew a dog whistle and rewarded her with a fish and lavish praise.

"Or we can ask her to touch a specific person, like—" Dulcie scanned the faces across the tank "—Jill." Jill had been a volunteer for two years now. Misty had had some difficulty lately learning key-names for new interns, presumably because there were already so many keys on the keyboard.

Ian hit "MISTY PEC-TOUCH JILL." Misty zoomed away again, lifted her head to look at the people around the tank, stopped in front of Jill, a young dark-haired woman, and touched her arm. Ian blew the whistle again and cheered as Misty came sailing back.

"We can also ask her to touch every person in the tank." She nodded to Ian.

"MISTY PEC-TOUCH PEOPLE."

Misty quickly grazed each arm with her pectoral fin.

"Very impressive," Admiral Pangborn said distractedly. "I understand you can also have the dolphins use the keyboard?"

Dulcie's jaw muscles tightened. "Of course. We can skip ahead to that, if you like. Misty has been using this keyboard for over ten years now. We've taught her how to report on what she sees, in essence to describe the action taking place. Ian, toss in a few objects, would you?"

Ian threw two small beach balls, a Fris-

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bee, and a knotted rope into the tank. He called across to Mary, Sport's trainer, "Let's get ready for some description trials."

"You'll notice that Ian is hitting MISTY OBSERVE. That means Misty has to watch what's going on so she can describe it for us. Mary, have Sport blow bubbles."

Mary gave a hand-signal. Sport sank down and emitted a stream of bubbles from his blowhole, culminating in a bubble-ring.

"Now Ian hits MISTY DESCRIBE. Misty has to tell us what just happened. Note that there are two correct answers, SPORT MAKE BUBBLES and DOLPHIN MAKE BUBBLES."

Misty ducked under the water and hit "DOLPHIN MAKE BUBBLES."

"Hm," Pangborn said.

"Let's try another," Dulcie said hurriedly, before he asked to move on again. She wanted to show him her favorite part of the keyboard work. "Mary, have Sport tail-touch a Frisbee."

Mary signed to Sport, who swam around until he found the Frisbee, then touched it with his tail.

Ian pressed, "MISTY DESCRIBE."

Misty hit, "DOLPHIN TAIL-TOUCH FRISBEE."

"We've taken this one step further," Dulcie said with a grin. "To demonstrate that dolphins have a sense of where an action is in a sequence of events, we can have her describe the action before or after the one she just described. It's a short step from here to cause-and-effect, which is where we plan to go next. Ian?"

"MISTY DESCRIBE SPORT ACTION BEFORE."

Misty considered for a moment, then pressed "SPORT MAKE BUBBLES."

"MISTY DESCRIBE SPORT ACTION AFTER."

"SPORT TAIL-TOUCH FRISBEE."

"So your animals can work with the concepts of past and future," Pangborn said, nodding. "What about present?"

Dulcie laughed. "Oh, dolphins understand the present. When they want something, believe me, they want it now."

Lieutenant Fox smiled.

"As far as the keyboard work goes, we can have Misty describe actions as they're happening, sort of play-by-play."

"Very provocative work," Pangborn said, exchanging a glance with Fox.

"There's more. We can also have Misty observe an action, then describe the action ourselves and ask her if we're right or wrong. That's what the 'Yes' and 'No' buttons are for."

"Just how extensive is your ability to communicate abstract concepts back and forth?"

"Well, we're very excited about our new research project, which involves having one dolphin relay instructions to another."

"Yes, I've heard about that one. That's one the Navy asked for specifically," Pangborn said. "How is it progressing?"

"There's been a steep learning curve," Dulcie admitted. "Steeper than I expected. But two of our dolphins, Misty and Boomer, seem to be able to relay instructions to the others. The problem is that we have to use dominant animals to relay the instructions; a dominant animal won't listen to instructions from a lower animal in the social structure. Luckily, Misty and Boomer are both older, larger, dominant animals."

"I'd like to see that, if it's possible."

Dulcie pursed her lips. "We'll give it a shot, though I can't promise it'll go perfectly. Ian, let's have Misty tell Sport to do a backflip."

Ian keyed in, "MISTY TELL SPORT BACKFLIP."

"Sport's trainer is telling him to listen for his instruction," Dulcie explained as Mary touched a hand to her ear.

Sport zoomed away from his trainer and leaped backwards in the middle of the tank.

"Can they do more complicated things?" Pangborn asked.

Dulcie grinned. "They can. We can

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have Misty give another dolphin a message, and have that dolphin repeat the message on its own keyboard."

"I'd like to see that."

Dulcie called instructions to Colin, a volunteer who was training a female dolphin named Hannah in the next tank. "Let's head over to Hannah's keyboard so you can see the message come out the other side. Ian, toss in a ball and a Frisbee. When I give the signal, tell Misty, 'MISTY TELL HANNAH REPEAT: BALL AND FRISBEE IN.'"

They headed to the keyboard by Hannah's tank. Colin directed Hannah's attention to the other tank.

Dulcie signaled Ian, who hit the keys. A few moments later, Misty started whistling and buzzing. Hannah whirled and hit "BALL AND ROPE IN" on her keyboard.

"She didn't get the whole thing," Pangborn said, frowning.

"True. Hannah doesn't have as much keyboard experience as Misty has. But she got most of it. We'll try the same one again. Ian?"

This time, Hannah hit, "BALL AND FRISBEE IN."

"There we go," Dulcie said.

"Well, well," Admiral Pangborn said. "This is extremely impressive work. I'm pleased with the progress you've made here. I can tell you that no other lab in the country has gone as far with interactive communication as you have. Doctor Huber, I'd like a word with you in private, please."

Dulcie's excitement soured into frustration. "There's more to the demo."

"I've seen what I need to see. A word, please. It's important."

His serious tone quelled her anger. "We're done here," she said to Ian.

"ALL DONE," he keyed, the traditional end to the session or the day.

"ALL DONE," Misty responded.

Dulcie showed him and Lieutenant Fox to her office. Admiral Pangborn had his other staff members wait just outside.

"Please sit down," she said, closing the door. "What's going on?"

"We have some questions for you," Pangborn said, nodding at Fox.

"Have you noticed any changes in your dolphins' behavior anytime in the last six months or so?" Fox asked, pulling out an electronic notepad.

"What kinds of changes?"

"Irritability, slower learning curves, erratic or aggressive behavior. Even subtle changes."

"I haven't really paid close attention," Dulcie said. "I'm not out there every day. Ian manages the day-to-day research. But no, I haven't heard him mention anything like that."

"Any pregnancies this year?"

"No. That's maybe slightly unusual. They're pretty frisky, but the females don't always conceive."

"Have you or your staff noticed any unusual or reduced sexual activity?"

"Again, not that I'm aware of."

"Do you keep logs of activity in the tanks?"

Dulcie nodded. "Both during and outside of research sessions."

Pangborn said, "We'd appreciate it if you would have someone collate that information and see if you can spot any trends."

"What's this all about?" Dulcie asked. Their sober manner was making her nervous. "What's wrong?"

"These are routine questions, Doctor Huber," Pangborn said. "We're just trying to ascertain how stable an environment this is for the animals and the research that the Navy is funding. The behavior of the animals is a good barometer for the facility's atmosphere. Your lab seems exemplary."

"Thank you," Dulcie said warily.

"There is something we need to discuss," Pangborn said, sitting back in his seat. "We have a wild dolphin that we need to find temporary housing for. I understand you have a quarantine tank, somewhere completely isolated from your main tanks."

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"Admiral Pangborn," Dulcie said, "we can't take any strange animals in right now, not with the epidemic I've been hearing about. As I'm sure Lieutenant Fox is aware, there's an outbreak of something like rabies in wild cetacean populations. It spreads rapidly to captive animals kept in pens open to the ocean, so it's highly contagious. Nobody knows the vector by which this disease is transmitted. Pretty much all dolphin facilities have quarantine rules in effect."

"I understand your reluctance," Pangborn said, "but we have no other place for her right now. Your quarantine tank is thirty feet away from your six other tanks, and it runs on a different water supply."

"I'm sorry, but it's out of the question."

"Doctor, this must be a very expensive place to run. Dolphins eat what, at least twenty pounds of fish a day?"

Her shoulders tightened. "About twenty-five."

"And you have eight dolphins here. That's a lot of fish. Then there's tank maintenance, electricity, vet bills, not to mention salaries and research equipment. I would estimate that Navy grants account for at least three-quarters of your operating costs."

It was closer to eighty-five percent. "Admiral, are you threatening to reduce our funding?"

He leaned in. "Between you and me, Doctor, I have full authority to cut you off without a dime, effective immediately, if you don't cooperate with us."

For a moment, Dulcie couldn't even speak. Through clenched teeth, she said, "What's so important about this dolphin?"

"That's classified. I can tell you that Lieutenant Fox has run full physicals on her, including bloodwork, and she's healthy."

Dulcie frowned. She couldn't afford to lose the Navy's funding. "How long would you need to keep her here?"

"Not long. A few weeks, couple of months at most. We should have other arrangements by then. I can guarantee you that Navy personnel will be responsible for feeding her, and will go through appropriate decontamination procedures afterwards until you're comfortable that she isn't going to make your animals sick."

"I don't like the risk."

"I understand that. The Navy is prepared to compensate you for the inconvenience. We'll kick in an extra million dollars over the next three years toward your funding, to be used for continuing your keyboard research."

The stick and the carrot both, she thought. *They must want this very badly.* She took a deep breath. "She had better be out of here in two months' time."

"Glad we could work this out. Here, we'll need you and each of your staff to sign one of these." Pangborn produced a sheaf of documents and laid it on her desk. "It's a nondisclosure agreement about the research we'll be conducting. It's standard for all facilities housing Navy animals."

"I'll have to read it over."

"Certainly. We'll pick them up today at fourteen hundred hours, when the wild dolphin arrives. That's two o'clock today."

"Today?! But we're not prepared!"

"Your quarantine tank is unoccupied," Fox said. "We'll take care of unloading her."

"Two o'clock today," Pangborn repeated, rising. He and Fox left.

Head spinning with rage and confusion, Dulcie sat back in her chair, trying to figure out what had just happened, and why.

At five minutes to two, a jeep and a large canvas-backed truck full of Navy personnel pulled up. *Soldiers?* Dulcie wondered. *SEALs?* The only thing she knew about the Navy was how much money they were funneling into her lab.

"You have those NDA's for me?" Pangborn asked Dulcie, coming up to the

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main entrance.

Dulcie handed him the sheaf of signed papers. Most of the NDA had been pretty standard, but the clause at the end raised her hackles. "Why that part about lab staff not interacting with the lab dolphins while the new dolphin is being unloaded, and for a full two days thereafter?"

"Standard precaution," Fox said briskly. "It's for your safety. There's bound to be a lot of turmoil with new animals being introduced, even in another tank. We want to keep you out of harm's way."

"I'm fully aware of how my animals react to newcomers. Half of my dolphins came from other facilities."

"Protocol is protocol," Pangborn said. "Now, we need you to gate your dolphins into as many separate tanks as possible."

"Protocol again," Fox said with an apologetic smile. "We've found this to be an excellent way of keeping behavioral disruption to a minimum. They won't be able to stampede each other as easily if they're in separate tanks."

"You don't know my dolphins," Dulcie muttered, but she called Ian over and asked him to carry out Fox's instructions.

Once the eight lab dolphins were separated into the six available tanks, Pangborn pulled out a military cell phone and gave some instructions in a low voice. A few minutes later, a large, covered Navy truck pulled up outside the lab.

With minimal fuss, the Navy staff unloaded the new dolphin. Four Navy staff positioned themselves around the quarantine tank; four more wandered around the other tanks, keeping a respectful distance. Their rifles made Dulcie uncomfortable.

Through windows in the quarantine and regular tanks, the wild dolphin and the lab dolphins could see each other. The newcomer started a great deal of clamor, whistling and buzzing furiously.

The rest of the tanks erupted into a frenzy. The lab dolphins sped around their tanks, eyes wide, movements jerky. They churned the water into foam.

With a keening distress whistle, Sport banged his head against the metal gate that separated him from his mother.

Reflexively, Dulcie started toward his tank.

Pangborn grabbed her arm. "You can't go over there now. You need to leave him alone."

She wrenched herself free. "He's going to hurt himself."

"It could be dangerous!"

"I've known him all his life. I helped *deliver* him. He's scared, and he needs me!" She ran for Sport's tank.

An open gash on Sport's forehead bled freely. He didn't seem to notice. Whistling plaintively, he kept banging against the gate.

"Hey now," Dulcie called soothingly, kicking off her shoes. She swung her legs over the tank wall, slid slowly into the water fifteen feet away from him. "Sport, take it easy."

He whirled around. His eyes bugged out.

Shrieking, he charged her.

Dulcie had no time to react. She heard a "pop." Absurdly, red feathers bloomed on Sport's skin. Then she was being yanked out of the water by strong arms. Pain seared her foot.

Next thing she knew, she was standing outside the tank, supported by two Navy men. "What the—"

"What did you do?" Fox yelled, running over. He ignored Dulcie, looking into the tank. Sport was barely moving. "You shot him!"

"Tranquilizer dart, sir," said one Navy guard. "Admiral's orders."

"Tranquilizer," Dulcie repeated. Her eyes met Fox's. "Oh, God."

He looked as panicked as she felt. "Do you have an artificial respirator, like for surgery?"

"In the medical office behind the quarantine tank. Ian!"

"On it," Ian said grimly, racing toward

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the office.

Sport moved his tail weakly a few times, then sank to the bottom of his tank. Misty whistled piercingly and rammed the gate, but it held.

Pangborn came over. "I told you to stay out of that tank."

"You authorized tranquilizer darts?!" Fox demanded.

"You know it's a dangerous situation," Pangborn said, eyes narrowing. "I didn't want to just shoot them if there was trouble. What's the problem?"

"Dolphins are voluntary breathers, you asshole!" Dulcie shouted. "They don't breathe when they're unconscious. If we don't get him into the respirator in time, he'll suffocate!"

It took six of her staff to get Sport's lax body into the canvas dolphin transport on the tank's shallow platform. The transport was like a travois, two parallel poles with a canvas sling in between. Her six staff stood in water about waist-deep, holding the poles to keep the unconscious dolphin upright.

"Have you used one of these before?" she asked Fox as he wrestled the artificial breather into place. PVC pipes made a scaffolding around the dolphin's body.

"Lots of times." He expertly pried open Sport's blowhole and, gently, pushed a plastic tube deep inside. "That should do it. We plugged in?"

"Yeah," Ian said.

"Start 'er up. One respiration per ten seconds for now, very shallow. He's just a little guy."

The machine started humming. Sport's sides inflated slightly.

The lab staff whooped and cheered.

"Time," Dulcie said, looking at Ian.

"Three minutes, forty seconds," he said.

"He should be all right," Fox said with a relieved grin, listening to Sport's heartbeat with his stethoscope. "Since he's under, you got any surgery you want done on him?"

Dulcie glared at him. *"What?!!"*

He held up his hands. "Sorry, bad joke. Just trying to lighten the mood."

She took a deep breath. "How long will he be out?"

Fox inspected the dart he'd pulled from Sport's body. "Shouldn't be more than two, three hours at most. We need to lower the water level in the tank for when he wakes up."

"Should we give him epinephrine, to wake him up?"

"I don't think so, not yet. We've got him breathing and stabilized. His heart rate seems fine. I don't want to risk a drug interaction. Here, I'll just take a look at that cut on his forehead."

Dulcie tried to breathe deeply, but she was shaking too badly. "You!" She turned to the Navy guard with the tranquilizer rifle. "You imbecile! You—you shot my dolphin!"

"Following orders, ma'am," he said, imperturbably.

"He probably saved your life," Fox said.

She glared at him. "Bullshit. Sport never hurt me in his life. He never would."

"Really. Look down. You'd better come with me so we can get that looked at."

Only then did she notice the blood pooling around her bruised foot.

After Fox dressed the rake-marks left by Sport's teeth and determined that her foot had no broken bones, Dulcie spent half an hour screaming at Admiral Pangborn, describing his unlikely genealogy and personal habits, and threatening to take his actions to the highest level of the Navy. He listened calmly until she wound down.

"You go right ahead," he said. "Maybe you can also explain why you disobeyed a direct order to stay out of that tank."

"I don't take orders from you!"

He muttered something under his breath. It sounded like "Civilians."

She took a deep breath. "Something is going on here. Something big. You bring in your mystery dolphin, and all of a sudden my dolphin attacks me, which he's

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never done before. I want to know exactly what's going on here, and I want to know *now!*"

"All right," he said, surprising her. He held up the sheaf of NDA's. "But you better remember these. Any word of this gets out, and you'll find out that you do answer to the U.S. military, whether you like it or not."

"Just tell me what's going on!"

He called Fox into Dulcie's office and closed the door behind him.

"How much do you know about what's been going on in the oceans, regarding whales and dolphins, over the past month?"

Surprised, Dulcie said, "I know there have been a lot of attacks on people, even in places like Monkey Mia in Australia, where the dolphins are usually friendly. I've heard reports of some random whale attacks on fishing boats and sailboats."

"There's nothing random about them," Pangborn said. "Doctor, I'm about to let you in on a very dangerous secret. The only reason I'm telling you is that I need your full cooperation—your country needs your full cooperation. You're in a unique position to help us with an urgent situation."

Dulcie's eyes narrowed. "After the way you bullied me into letting that wild dolphin stay here, I don't know if I want to help you."

Pangborn looked at her as if weighing what to say. "There's no such thing as cetacean rabies. That's disinformation leaked to the press to buy us some time."

Dulcie frowned. "Are you saying the attacks aren't real?"

"Oh, they're real, all right. They're far more pervasive than you think. More than three quarters of all vessels in the ocean have sustained damage from whale and dolphin attacks. Every beach I know of is closed, because it isn't safe to go in the water anymore."

"I thought the beaches were closed because of oil spills or toxic waste or something," Dulcie said.

"That's exactly what you were supposed to think." He looked up at Fox.

"About three weeks ago," Fox said, "we got a report of a shark attack on a snorkeler in Hawaii. The snorkeler lost a leg. Frankly, he's lucky to be alive. His story was that a dolphin approached him to warn him that sharks were coming, but it was too late; the sharks got him before he could get to shore. But the amputated leg showed clear signs that the dolphin, not the sharks, attacked him first. There were deep rake marks from knee to ankle. The shark bites came afterwards."

"What are you saying?"

"We believe that the dolphin incited nearby sharks to attack by raking the man's leg and making him bleed underwater."

"You're nuts. That's just not how cetaceans behave."

"That same story has been played out numerous times. Some fishermen saw dolphins tease and herd sharks to a heavily populated beach in Florida, then dart in and draw blood from several swimmers. The dolphins retreated while the sharks got to work."

Dulcie just stared at him, uncomprehending. "What does this have to do with cetacean rabies?"

"The evidence is overwhelming," Pangborn said. "Whales and dolphins are attacking boats—we have reports of gray whales, orcas, and harbor porpoises working in concert to ram boats in Puget Sound. It's happening all over the world. These attacks are systematic, planned, and coordinated."

He paused, looked at her. "Doctor Huber, we are at war. And we don't even know why."

"War," she breathed. "You're not making any sense."

"There's no other way to explain it. We're seeing cooperation between normally antagonistic species of cetaceans. Orcas and harbor porpoises don't usually cooperate; orcas prey on porpoises.

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The attacks started three to four weeks ago, at approximately the same time. It's a worldwide emergency." Pangborn exchanged a look with Fox. "There's more. All captive cetaceans exposed to wild cetaceans have started attacking their trainers. Our best guess is that the wild cetaceans are transmitting the message of war to their captive counterparts."

The blood drained from her face. "That dolphin you brought in—she did something to my dolphins!"

"We had to see what would happen. If our theory was correct, the wild dolphin brought the message of war and communicated it to your animals, who hadn't known of it before."

Shaking with rage, she said, "You used me. You used my lab, my animals—you put my staff in danger, without even telling us! You purposely turned my dolphins against me! You bastard!" She leaped to her feet, knocking over her chair. "Get out!"

Pangborn stood, an imposing presence. "We're not done here yet."

"Then I'm leaving!" Dulcie stormed out of her office.

And was brought up short by two armed Navy staff, a man and a woman, blocking her path. When she tried to move past them, they brought their rifles up slightly, not quite aimed at her. The threat was clear.

Not soldiers or SEALs, then, she thought bitterly. *Guards.*

"Doctor," Pangborn said, "sit down."

Her heart pounded; her head swam. Shaking, she folded her arms and stood just inside the door. The Navy guards closed it behind her. "This is insanity! You have no right—my God, what do you want from me?"

"We need your help. This nation is in a state of crisis."

"Because of some whale attacks?"

"Because not every country believes they *are* whale attacks. Some of our third-world neighbors think we engineered these attacks, either with trained animals or with Navy SEALs. We've tried to downplay the severity of these incidents in the media, but unrest is growing rapidly, and the attacks are increasing in frequency. We need to find out why cetaceans have declared war on us, and we need to end the war before some trigger-happy third-world idiot starts World War Three."

"It really is an international crisis," Fox said softly. "Believe me, we wouldn't be putting you through all this for anything less."

Head whirling, Dulcie sank into a chair. She tried to sort through the barrage of information. Panic nibbled at her thoughts; she took some deep breaths and tried to calm herself down. She couldn't believe she'd just had guns pointed at her. She couldn't believe that she wasn't allowed to leave her own office.

And she couldn't believe what she was hearing about whales deciding they were at war with the whole human race.

But if. If Pangborn was right. If there was a pattern of attacks, like he'd said—what other explanation was there? Could it be true? Or was he lying to her, as he had lied about it being safe to bring in the wild dolphin? How could she trust him?

And Fox, the Navy veterinarian, was in on this too. She had seen how fast and hard he had worked to save Sport's life. She wanted to trust him, even though Pangborn set her teeth on edge.

She looked up at Fox. "You believe this?"

"Every word," he said. "I'm sorry we had to deceive you before. I truly am. But this is a crisis, and we have to find an answer as fast as possible. We're not talking about a few swimmers in danger, we're talking about preventing war between countries with nuclear capabilities. Look, I didn't believe it at first either. But I've seen the evidence, read the reports. I've even done flyovers in helicopters and witnessed some of these attacks myself. The whales haven't gone crazy. There is no evidence of a new

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virus, no dramatic changes in the necropsy reports on stranded animals. We don't know why they're attacking us. And we need to find out. Desperately."

"That's why we're here," Pangborn said. "It's my job to find a way to end this war. I'd prefer to do so in a way that saves lives, human and cetacean both."

Dulcie's stomach tightened. "What do you mean?"

"Doctor, you know how close ancient whalers came to killing off entire whale species. The blue whale is still on the endangered list. And that was with primitive vessels and weaponry. If we don't find a way to stop cetaceans from attacking people and boats, the military will launch an all-out offensive against all cetaceans."

For a moment, she couldn't breathe. "You'd kill them all?"

"As many as we needed to, to stop this war. My superiors aren't willing to wait long before heading down that road. I need to bring them results fast to persuade them that we have another alternative."

"How long do you have?"

"Today and tomorrow. Probably the next day, if I can show we're making progress. Not much more than four more days at most. Businesses are losing too much money from whale attacks. They're clamoring for military intervention. And we can't keep the dolphin rabies story going much longer. People are starting to figure out that it doesn't fit the facts."

Dulcie stared at him, unable to form words. Pangborn opened his mouth, but she raised her hand. "No. Just—no. God, this is insane. It's a nightmare. I can't—no. It's too much."

Fox said, "Doctor Huber—Dulcie—we really need your help. I know it's a lot to take in all at once. We've had a few weeks to get used to the idea, but it's all brand new to you. I know we're not your favorite people right now, but don't think of it as helping us. Think of it as saving the lives of millions of whales and dolphins. I'm sure you want to do everything you can to prevent their deaths."

Dulcie sat quietly for a few minutes, trying to sort out her thoughts. She held a hand to her twisting gut, trying to steady it. Finally, she looked up at Pangborn. "Why here?"

"A lot of dolphin labs are doing impressive research, but you're the only one who's gone this far working with the kind of interactive communication that might help us find some answers."

The room spun around her. She forced herself to focus on the words as if they were an abstract puzzle that she could solve. "I don't get it."

"Your interactive keyboard. It's primitive, but it's our best chance at finding out what's going on."

"How?"

"You ask your dolphins why they're attacking us. Assuming we get answers we can work with, we figure out a way for your dolphins to translate some questions or instructions to our wild dolphin. We'll ferry the wild dolphin back and forth between this lab and a sea-pen on the coast about half an hour from here."

"The idea is to create a translation system, using the keyboard, your dolphins, and our dolphin as cogs in the machine," Fox said. "We know it's a long shot, believe me. But it's our best shot at figuring out what's going on."

"I need a minute," Dulcie whispered. "Just give me a minute." Her breath was coming in gasps; she made an effort to breathe slowly and deeply. "This is why the Navy increased my funding, then."

Pangborn nodded.

"You want to use my dolphins as translators? And yours as a messenger? I don't see how it can possibly work. We just don't have the vocabulary for this kind of thing."

Nodding, Pangborn said, "Then we'll have to improvise."

Dulcie insisted on bringing Ian into their planning sessions. He worked more regularly with the keyboard than she

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did. The four of them started brainstorming how to use the keyboard to accomplish their goal. When Dulcie's mind started clouding, she realized her stomach was growling and she hadn't eaten all day.

"You guys want some pizza?" she asked, reaching for the phone. "I'm starved."

"I'm in," Ian said, leaning back and stretching till his toes shook.

Fox hesitated. "Do you know what they use to make it? I have this wheat problem—"

She grinned. "No problem. I used to be gluten-intolerant too. But the pizza place I order from uses only Bg wheat, the kind engineered to be—"

"—more digestible. I know," he said, relieved. "Miracles of modern science. Sometimes they really get genetic engineering right."

Thoughts of Bt corn and monarch butterflies sobered her. "Sometimes they do."

Two empty pizza boxes lay on the floor; a third, with a few slices left, sat on the corner of Dulcie's desk.

Dulcie looked up at the clock. It was six-thirty. She frowned and called Ian into her office. "How's Sport?"

"Still out cold," he said, looking grim. He glared at Pangborn, who ignored him.

"It's been over three hours," Dulcie said to Fox, who had excused himself frequently to check on the young dolphin. "I'm getting worried."

"We have other matters to worry about," Pangborn said.

"This won't take long," Fox said evenly. "We can't afford to lose even one of the keyboard-trained dolphins; we don't know which one will be best able to transmit our messages."

Pangborn grunted.

Dulcie hid a smile; she suspected Fox didn't buy his own line of bullshit. He just wanted to help Sport.

Fox splashed into the knee-high water in Sport's tank and examined the unconscious dolphin. "His heartbeat is still steady. At this point, we could try administering epinephrine. The tranquilizer ought to have worn off by now, so there shouldn't be any drug interactions. Maybe he just needs a little kick in the pants."

She remembered Sport charging her. Her heart lurched. "How will he react to us when he wakes up?"

"If we get him out of the water, he should be all right. In other facilities, since the attacks started, they typically get meek when their tanks are drained. We'll just need to find a way to get him back into the water without risking our own safety. Tell you what. We'll pull him up onto that platform—" because the water level was so low, the ledge was completely dry "—and give him a jolt of epinephrine, see if he comes around in a few minutes. If he does, we can slide him into the water without going in ourselves."

"Let's try it," Dulcie said.

Several lab staff got together, carefully lifting dolphin, PVC scaffolding, and the artificial respirator onto the platform. Fox administered an epinephrine injection.

A few moments later, to Dulcie's relief, Sport moved his tail weakly. Feeling the canvas around him and the tubing in his blowhole, he panicked a little.

"Easy there, fella," Dulcie said soothingly. She kept her hands well away from his sharp teeth. "We need to keep him out here a little longer, to make sure he won't pass out again." Her staff nodded.

Fox shut off the artificial respirator and carefully removed the tube from Sport's blowhole.

Sport whistled a distress call, over and over. In another tank, Misty called back.

"He's perking up," Fox said. "I'd say if he stays alert for another half hour, we can cut him loose."

Dulcie brought over a hose and sprayed Sport down with cool water.

Half an hour later, Sport was still alert,

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rolling his eyes at his human handlers.

"It should be safe," Fox said, crouching down. When he laid his stethoscope against Sport's chest, the dolphin flinched. "Easy does it. We're trying to help. Yep, he sounds fine, and he doesn't show any signs of losing consciousness again. He really needs to be back in the water."

Reluctantly, Dulcie agreed. "All right, people, let's move to the edge and tip him forward. Carefully—the water's pretty shallow."

Her staff gently jiggled Sport out of the canvas transport. He slid down into the water and shot across the tank, then started circling the perimeter slowly.

"You sure he'll be all right?" Dulcie asked. "He still looks woozy."

"I think he'll be fine," Fox said. "I'm just surprised he didn't shake it off on his own. That must've been a bigger dose of tranquilizer than I thought."

"We need to get started," Pangborn said from behind them. "Time is short."

"All right," Dulcie said. "Jill, keep an eye on Sport and let us know the instant he does anything abnormal. And slowly raise the water level."

They went to the keyboard by Misty's tank.

"I'm sure Misty saw the ruckus with Sport earlier," Dulcie said. "He was in the next tank. Let's see what we can find out. Ian, key in MISTY DESCRIBE SPORT ACTION."

Ian complied.

Misty eyed them thoughtfully, floating in the water.

"She's not going to cooperate," Pangborn muttered.

"Give me a minute with her," Dulcie said quietly. "Everyone, please, go into the offices. You too, Ian."

Pangborn frowned but complied.

Dulcie took a seat at the keyboard and looked at Misty through the underwater window. The dolphin watched her.

Dulcie cleared the keyboard. "SPORT SICK BEFORE," she keyed in. *Sport was sick earlier.* Misty knew "SICK" from the rare times a lab dolphin had gotten ill. When Dulcie brought vets in, she used the "HEAL" key to explain what they were doing. "DULCIE HEAL SPORT BEFORE." *I helped him.* "SPORT SICK NOT NOW." *Sport isn't sick anymore.*

She went to the window and crouched next to it. Misty clapped her jaws warningly. This close up, Dulcie could see viscous liquid seeping from her eyes. Though dolphins' eyes always secreted thick fluid, they only leaked this much when the dolphin was extremely upset.

Dulcie's own eyes felt hot, heavy. "Misty. Please. I want to help you. At least talk to me. For old times' sake." She pressed her hand against the Plexiglas.

Misty cocked an eye over to Sport's tank. Her son was swimming slowly, still tired but fully awake. "DULCIE HEAL SPORT PAST."

Dulcie started crying. "Maybe you don't hate me," she whispered. "Oh God, Misty, thank you." She took a moment to compose herself, then fetched the others.

"MISTY DESCRIBE SPORT ACTION," Ian keyed in again.

"SPORT SWIM," Misty keyed back.

Ian blew a whistle and tossed in a fish from a safe distance. "MISTY DESCRIBE SPORT ACTION BEFORE." *Tell us what he did earlier, before the swim.*

"SPORT FLOAT."

Again, a fish. "MISTY DESCRIBE SPORT ACTION BEFORE." *And before that.*

Misty jerked. "SPORT MOUTH DULCIE." It was the closest she could come to saying Sport had bitten Dulcie.

Fox whistled. "We're getting somewhere."

"Give her a fish," Dulcie said. "Let's see if we can get some clarification."

"MORE," Ian keyed in. *Give us more detail.*

Misty considered. She drifted back, away from the keyboard.

"Is she refusing to cooperate?" Fox

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asked.

"No, she's just thinking," Dulcie said. Ian nodded without looking at them. "Give her a little time."

Misty moved toward the keyboard again. "SPORT MOUTH DULCIE."

"Try again," Dulcie said.

"MORE," Ian keyed.

Misty squawked. "SPORT MOUTH DULCIE."

"She doesn't know how to elaborate," Dulcie said. "Let's see if we can give her a hand, play some 'twenty questions.' Ian, try this: 'MISTY REPORT. SPORT WANT PUSH DULCIE.'" To the Navy men, she said, "She'll hit either YES or NO to report on the statement's accuracy."

Misty hung in front of the keyboard, considering. "YES."

"More," Dulcie said.

"MORE," Ian keyed.

After a moment, Misty keyed, "SPORT WANT PUSH DULCIE. SPORT WANT PUSH THROW DULCIE."

"Give her two fish," Dulcie said. "So he wanted to throw me and push me."

"Throw and push?" Pangborn repeated. "But why?"

"Wait," Dulcie breathed. "Ian, throw in a Frisbee. Good. Now try MISTY THROW FRISBEE. MISTY PUSH FRISBEE. Let's see if we can get her to show us what Sport was trying to do to me."

But Misty just tossed and then knocked the Frisbee aside, following the instructions literally.

"We don't have enough damned keys," Ian said. "Neither of us can be clear."

Inspiration hit Dulcie. "OBJECT NAME PERSON." To Pangborn, "I'm telling her that the object in the tank is a person."

Ian nodded and hit the keys.

Misty jerked and squawked, then whirled, head bobbing, scanning the tank with sonar. She found no person in it. Movements jerky, she turned back to the keyboard.

"Again. OBJECT NAME PERSON."

Ian complied.

"Now try MISTY THROW PERSON. MISTY PUSH PERSON."

But before Ian could key in the new instructions, Misty rolled her head back, eyes bugging out. She dove underneath the Frisbee and smacked it so hard with her tail that it flew out of the tank and hit the wall of the office building.

"Well, now," Ian muttered.

"MISTY REPORT," Dulcie said quickly. "SPORT WANT PERSON OUT. Ian, try it." OUT was a command they used at the end of the day, to ask the dolphins to bring them all the toys left in the tank for removal.

Ian hit the keys.

Misty rammed into the "YES" key over and over again. "YES YES YES YES."

"We should try MISTY REPORT. MISTY WANT PEOPLE OUT." Ian suggested, his voice tense. At Dulcie's nod, he did.

"YES YES YES."

Through a suddenly dry throat, Dulcie said, "Ian, ask her if we can put a person in the water."

"DULCIE REQUEST PERSON IN."

As soon as his fingers hit the last key, Misty exploded into wild-eyed action, slapping the water's surface with her tail. She rammed the keyboard, "NO NO."

"I do believe," Dulcie said in a harsh whisper, "that we have our answer. They want us out of the water. All of us. Maybe that's why they've been attacking us—to push us out of their territory."

"Can you ask in another way?" Pangborn said. "To be sure?"

"MISTY REPORT. DOLPHINS WANT PEOPLE OUT," Dulcie said, voice flat.

Ian keyed in the phrase.

Misty hit, "YES YES YES PEOPLE OUT PEOPLE OUT PEOPLE OUT."

"But why?" Fox asked. "Why now?"

"Ian, let me in there," Dulcie said. He moved aside, and she sat down. "MISTY REPORT. DOLPHINS PUSH PEOPLE OUT. DOLPHINS WANT PEOPLE OUT. MORE."

Misty hung in the water.

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"MORE," Dulcie repeated. "MORE MORE MORE MORE." Aloud, "Tell us more, tell us why!"

With a muffled squawk, Misty sank to the floor of the tank.

"She's frustrated," Ian said. "She doesn't know how to express whatever the reason is. Maybe we should take a break before she gets too burned out to talk to us at all."

Dulcie nodded. She cleared the board. "MISTY FISH NOW QUESTION." *Does Misty want some fish now?*

Misty came back to the surface and hit "YES."

"Finish her feed," Dulcie told Ian. "Then come into the office. We've still got a long way to go."

The sky glowed gold, rose, and lavender. In half an hour, dusk would turn to full night.

"We know more than we did," Fox said. "We know the dolphins, and presumably all cetaceans, want people out of the water. Or we think we know that, anyway."

Pangborn nodded. "It's a good operating hypothesis, and it's damned good results for one day's work. But we don't know why, and without that, we don't know how to negotiate."

Dulcie stifled a yawn. She had never been so tired, but she was too upset and bewildered to go home and sleep. "They never attacked us when we killed them for food, or when the Japanese fishermen slaughtered them every year at Iki Island, or when we filled their environment with toxins. They didn't ram the Makah ships in Puget Sound when they started whaling again in the late 1990s. Did we just pass some kind of threshold? Have we dumped in one barrel too many of toxic waste?"

"It would help if we could identify something, anything, that has changed in the past month, or maybe few months," Fox said. "I mean, there are more strandings than usual, and more whale and dolphin carcasses showing up near shore, but that kind of trend has happened before, never with results like these. For something on this scale, it would have to be something really big, something huge."

"We'll use a two-pronged attack," Pangborn said. "Lieutenant Fox, focus on studying Doctor Huber's behavioral logs and the necropsy reports from stranded animals. See if you can come up with a reason. Doctor Huber, we'll work together to try to come up with ways to use the keyboard's limited vocabulary to see what else your dolphins can tell us."

To Dulcie, Fox said, "You have someone collating your behavioral reports?"

"Shit," Dulcie said. "I forgot. Ian, we need someone to go through the last few months of behavioral reports and see if we can pull out any anomalies, especially any stable changes in behavior. Would you get someone on that? And then go home. You look beat."

"Look who's talking," Ian said, smiling. He got up and left.

"I've done some necropsies on animals stranded in the last month," Fox said, setting up his laptop on Dulcie's small office table. "And I have access to dozens more in the Navy's online database. At the time, I was still looking for a rabieslike virus. I'll take another look at my reports and see if I missed anything."

"I'll send out for coffee," Pangborn said. "This is going to be a late night."

Ian burst back into the office. "Dulcie," he said in a low voice. "Come out and take a look at this. Quietly."

Pangborn and Fox rose to their feet.

The four of them slipped out of the office and crept up a staircase to the observation deck that overlooked the tanks.

"There's not a lot of light," he whispered, "but look at Boomer and Hannah." The two dolphins were in the nearest tank, lazily cavorting and caressing as they often did after research sessions. They fondled each other's genital slits with their elongated snouts, then

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pressed their abdomens together.

"This isn't the time—" Dulcie began in a sharp whisper, but Fox held his hand up.

"Wait," he said. "Look. That's typical foreplay, right? And the female is rolling her belly toward the male's, inviting copulation. He's pressing against her, but—"

"Nothing's happening," Ian said. "They aren't mating."

"Check the behavioral logs," Dulcie said. "See if anyone else noted something similar." Softly, to herself, "No pregnancies this year."

"No pregnancies anywhere," Fox said heavily. "At other facilities, I mean. We've been to all the facilities on the west coast. I didn't think it was relevant, but I noticed. Lots of sex play, but no pregnancies. Maybe there's no copulation going on."

"But why?" Dulcie asked.

"That," Pangborn said, "is what we're going to find out."

A few hours later, after putting together a list of possible questions they could pose with the keyboard, Dulcie poured the cold dregs of her tea into her mug. "May I assume," she said, "that your explanation of why you were asking about behavioral anomalies earlier was bullshit? That you weren't checking out the stability of the environment, but looking for clues as to what's making cetaceans so nuts out there?"

"We needed to gather data," Pangborn said without a hint of apology.

"And you guys have been to a lot of dolphin labs, right? So what have you found elsewhere?"

Fox looked up from his laptop. "Nothing obvious. But after the research reports were collated, we found a slightly decreased learning curve in pretty much all the facilities over the past eight months or so. Hard to find statistical significance there, because there's so much individual variation in how fast a dolphin learns a given task, but a lot of folks were surprised, in hindsight, that their animals weren't picking up tasks faster. That and the lack of pregnancies." He looked at Dulcie. "Have you noticed slower learning curves here too?"

"Actually," Dulcie said slowly, "I think we have. It's weird, but usually once the first dolphin learns a brand-new task, subsequent dolphins pick it up much more quickly. Maybe they heard or saw what was going on, or maybe we figured out how to teach it to the first one and so our teaching curve improved. But I haven't noticed that recently. It takes the second, third, and fourth dolphins nearly as long to learn the task as it took the first one. I guess I never really thought about it before now, but I did think it was a little odd."

Fox sat back, rubbing his brow. "One thing I've noticed in these necropsy reports from the past few years. Typically when we find stranded cetaceans in the early spring, a certain percentage are pregnant. It's common to see entire pods stranded—healthy animals as well as sick ones—so we get a good cross-section of the population's health, morbid as that sounds. The percentage of pregnancies has been steadily decreasing over the past five years. I haven't seen a necropsy of a pregnant animal in over a year now. So it may not be a localized phenomenon."

"Let's say that maybe they've become sterile," Pangborn said. "Could they be aware of that? And if they are, could they actually blame us for that? That's pretty deep deductive reasoning—are they capable?"

"We haven't really found limits to what they're capable of," Dulcie said. "We're mostly limited by budgets, time, and our own creativity. If we had a perfect communication system, who knows what we'd discover they could do?"

"So you think it's possible."

"At least as possible as all cetaceans banding together and declaring war on humanity."

Fox shook his head. "But what does it all mean?"

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Dulcie tried to stifle a huge yawn, and failed. "It means it's time to get some rest. I've done as much as I can do today."

"I have to caution you against speaking about this to anyone," Pangborn said. "We can't afford for this information to get out prematurely."

"Don't worry," Dulcie said grumpily. "I'll be sleeping here anyway. I keep a cot in my office for these late nights. So if you gentlemen will excuse me, I'll see you in the morning."

"We'll be back at seven A.M.," Pangborn said, standing up. "I'll leave three units—guards—posted to be sure nothing goes wrong during the night."

She bit back an angry retort.

"Good night, Doctor Huber," Fox said.

Dulcie had hoped that sleep would bring temporary amnesia of the previous day's events. But as soon as her alarm went off, her mind snapped into focus. Grief poured through her. She found herself sobbing. Could she really have lost her friendship with Misty? With Sport, whom she'd always thought of as a nephew?

She felt incredibly lonely.

Rachel would understand—but Dulcie didn't dare call her, or any of her other colleagues. Not with her signature on that NDA, and those Navy guards right outside. Pangborn struck her as a hardened pragmatist. He wouldn't hesitate to arrest her if she broke her silence.

"We have to find an answer," she whispered, heaving her aching body out of her folding cot. Her foot throbbed under its bandages. "I can't have lost them for good."

She was just finishing breakfast when the Navy jeep arrived. Seven A.M. sharp.

"We ready to take another crack at that keyboard?" Pangborn asked. He looked as fit and alert as he had late the night before, which made Dulcie even crankier. She felt like a wreck, mind bleary, emotions running on full steam.

A Navy guard poked his head into Dulcie's office. "Sir? We got something you should see."

"I'll be back." Pangborn followed him out the door.

"You got any of that leftover pizza?" Fox asked, stretching in his chair. "I didn't have a chance to grab breakfast."

"In the mini-fridge. It's pretty good, huh?"

"It's a damned miracle," he said with a tired grin. "I guess I shouldn't be surprised that you have that gluten thing, too—I run into a lot of people who do. After years abstaining from wheat, there is just nothing like a slice of real pizza. Those rice-flour crusts just didn't hack it. I can't tell you how excited I was when they first put Bg wheat on the market."

"No kidding," Dulcie said. "Sometimes I wish I'd gone into genetic engineering instead of animal language research, just so I'd understand what the hell they were doing."

He snorted. "I don't think they know what the hell they're doing some of the time. I'm just grateful that they gave me back my pizza. And pastrami sandwiches."

"And sourdough. So what's the deal with Pangborn? Is he always this big an asshole?"

Startled, Fox glanced over at her. "Oh, he's not so bad. He's pretty much career military, and they don't believe in giving a lot of explanations. Sometimes they don't understand why everyone else doesn't see things their way. But he's a sharp guy, even if dolphins aren't his area of specialty."

"What is his specialty?"

Fox shrugged. "Not sure. But he has a reputation for getting problems solved. He's a pretty decent guy. I think he was the one who argued for trying to find a bloodless solution, instead of just starting an all-out offensive against whales and dolphins. And after that whole debacle with Sport, he actually took me aside and asked if there was anything else he should know about dolphins and that conscious/unconscious business. It was-

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n't exactly an apology, but it was clear that he wanted to avoid repeating any errors."

"So what did you tell him?"

"That cetaceans don't actually sleep, not in the sense we're used to, so true unconsciousness is an unnatural state for them. That there's evidence that they doze with one half of their brain at a time when they rest, and that they take little two- or three-minute catnaps at the surface sometimes. And, um," Fox colored slightly, "about erections."

Dulcie's own cheeks heated. "What about them?"

"You know, that males have complete voluntary control over their erections, so they don't get boners when they're unconscious." He looked away and took a bite of cold pizza.

"They know that for sure now? I'd heard theories—"

"It's a hard thing to prove—whoops, sorry, I mean a difficult thing to prove." He laughed self-consciously. "The only chances we get to observe unconscious dolphins are in surgical situations, where they wouldn't be prone to sexual response anyway. But it's the theory of record, based on the idea that cetaceans need to maintain their streamlining except in special circumstances, like mating."

Dulcie sat quietly for a moment, then said, "I wonder why they just believed it."

"Hm?"

"My dolphins. I wonder why they believed the war message."

Fox shrugged. "Maybe dolphins can't lie. I mean, sonar lets them look into each other's bodies, so maybe they never learned deceit."

"Or maybe," she said, "this message was so serious, so awful, that they knew it couldn't be a lie."

Pangborn returned, looking even stonier than usual. "Any progress?"

Fox straightened in his chair. Nibbling on a piece of cold pizza, he gestured at his laptop. "I'm waiting on some blood sample reports from the lab. Should be here soon. The only possible lead I've found has to do with the brain tissue of stranded animals. A lot of necropsy reports talk about lesions in the brain tissue, like you'd expect from *Morbillivirus*, a virus that caused a lot of cetacean illnesses and deaths about ten, fifteen years ago. But there are some inconsistencies—the new ones don't really seem to match typical *Morbillivirus* lesions. Which makes me wonder if maybe something else made them, and they were misdiagnosed. I wish I could do some of those necropsies over again."

"Well, you're in luck," Pangborn said grimly. "That wild dolphin we brought in yesterday died during the night."

The blood drained from Dulcie's face. "*What?!* But—but how? Why?"

"That's what Lieutenant Fox is going to determine," Pangborn said. "I'm having the carcass moved to a nearby medical lab. It should be there within the hour."

"On my way," Fox said, swallowing the last bite of pizza and grabbing his vet's bag.

Perversely, Dulcie felt both relieved and guilty about the dead dolphin. The sooner they had an answer to this puzzle, the sooner things would get back to normal. Maybe it was worth one death to put things right. But if a wild dolphin could be struck down unexpectedly here, what about her own dolphins?

"Doctor," Pangborn said, "the situation seems to be more urgent than we realized. We need to get to work. You ready?"

"Ready enough," she muttered, grabbing the list of questions from her desk. *Just a mental puzzle*, she told herself. She couldn't afford to deal with the enormity of the situation just yet. "I—I think we should start where we left off yesterday."

Pangborn nodded. "I want to focus on finding ways to negotiate."

"We have to find out what they want

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first," Dulcie said. "Besides us out of the water."

Ian had arrived early to supervise the dolphins' morning feed. Dulcie called him over to pilot the keyboard.

"Start out with MISTY BLOW BUBBLES," Dulcie said. "Something easy before we tackle the hard stuff."

Ian keyed in the command. Misty sank down to the tankside window and loosed a stream of bubbles from her blowhole. Ian tossed her a fish.

"Now MISTY REPORT. DOLPHINS WANT PEOPLE OUT."

As soon as the underwater keys lit up, Misty hit "YES YES YES PEOPLE OUT."

"Let's explore illness and pregnancy," Pangborn said. "Those are the two possible causes of aggression that Fox has come up with so far."

"MISTY REPORT," Dulcie instructed Ian. "MISTY BABY LATER?" *Are you pregnant?*

Misty's head jerked. "NO."

"HANNAH BABY LATER?"

"NO."

Dulcie ran through the rest of the female dolphins; Misty reported that none were pregnant.

"We already know that," Pangborn said, scowling.

"But we didn't know that she knew that," Dulcie said. "One more, Ian: DOLPHIN BABY LATER? I want to generalize."

Again, Misty hit "NO."

Dulcie's heart tightened. "Ask her for more information."

"MORE."

Misty squawked. "DOLPHIN BABY LATER NOT."

"She's just repeating what you said," Pangborn said.

"I know," Dulcie said. "That's good. It means she's tracking. OK, Ian. Try this: MISTY SICK?"

Misty hovered in front of the keyboard, undecided. Finally she hit "NO."

"HANNAH SICK?"

"NO."

"What about the males?" Pangborn asked.

"BOOMER SICK?"

Misty hesitated, floating in front of the NO button. She turned her head and hit "YES."

Dulcie ran through the other males, except for Sport—she didn't want to upset Misty any more. Misty reported that both other males were sick, while all five females were not.

"Have you noticed any abnormal behavior in the males?" Pangborn asked.

"No," Dulcie said, mystified. "They aren't acting sick."

"We should move on. We need to find something to bargain with."

They spent another hour trying to find out if there was anything else the dolphins wanted, but Misty would only repeat that they wanted PEOPLE OUT.

Fox returned in the early afternoon. He was frowning.

"What did you find out?" Dulcie asked.

"Those brain lesions—they're definitely not *Morbillivirus*."

"So what did cause them?"

"I'm not sure. All I can say is that something seems to be killing dolphin brain cells. I've sent blood samples to a Navy medical lab. Sir, I used your name to make sure they got top priority. They should be emailing me the results any time now—I'd better get on the laptop and patch into the Navy intranet."

In Dulcie's office, Fox settled himself at his laptop and checked his email. "Hey, they're in already. Looks like your name carries some clout, sir." He scanned the report intently. "Now that's—how strange."

"What?" Pangborn said impatiently.

"*Bacillus granieri*."

Dulcie frowned. Where had she heard that recently? Then she remembered. "That's that bacterium in Bg wheat, the symbiont that produces those enzymes. I read about it in an article about genetic engineering. But it's only supposed to be able to survive in conjunction with

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wheat. It's supposed to die off without the proper host."

"I know. But here it is, in high concentrations, especially in the gut samples. I can't explain it."

"What if," Dulcie said softly, "what if those bacteria can produce other things besides enzymes? What if in combination with wheat, they're relatively harmless, but when they're combined with algae, or plankton, or even herring and smelt—which they're not supposed to be able to live with—they end up producing a whole other set of chemicals?"

Fox leaned back, rubbing at his temple. "Jesus. We could be drugging the entire ocean."

"Bt corn," Dulcie said. "It's supposed to disrupt the development of corn borer larvae. But by accident, it also happened to damage Monarch butterfly caterpillars too. An unexpected side-effect. By the time they figured out what was going on, Bt corn accounted for over twenty-five percent of the corn being grown worldwide—and farmers refused to stop using it. I mean, you try telling a farmer to plant a kind of corn that will get eaten up by pests, instead of a kind that will produce a good yield. Same thing with Bg wheat. It's so much cheaper than traditional strains that it's just about everywhere."

"But how would this Bg bacterium get into the ocean?" Pangborn asked.

"Oh, a million ways," Fox said. "In human and animal feces. In the chaff that gets dumped into rivers that feed into the ocean. Bg wheat is extremely pervasive now, all over the world."

"If we can identify the problem," Pangborn said, "then we can devise a solution. Assuming Bg wheat really is the problem, we need to figure out what chemicals the bacteria produce in the oceans, and what effect those chemicals have on cetaceans."

An elusive thought was forming in Dulcie's mind. "They were sort of sluggish last night," she murmured, frowning. "They've been sluggish a lot lately, come to think of it. And it took Sport so long to recover from that tranquilizer, almost as if—"

"—as if he had already been drugged," Fox said with growing excitement. "With some kind of sedative. Maybe the bacteria, when combined with ocean flora, produce a soporific. Whales would be struggling just to stay awake."

Dulcie's jaw dropped. "They're dying because they're falling asleep. Breathing is a voluntary function, so if they fall deeply asleep, they suffocate and die. And if they only fall asleep for a short time and wake up—"

"—then they end up with brain damage, just like a person who stops breathing for several minutes, which would account for those brain lesions in the necropsies," Fox finished for her. "And it gets worse and worse, because we're just pouring more and more bacteria into the oceans every day."

"I read an article on Bg wheat just a couple of days ago," Dulcie said. "The bacteria are supposed to help relax and strengthen the digestive tract, right? The people marketing Bg wheat tell us the bacteria produce enzymes to do that, but maybe they produce muscle relaxants, sedatives, in minute amounts. So maybe the bacteria produce more sedatives in combination with, say, algae than they do with wheat."

"That would explain the death of the wild dolphin we brought in," Fox said. "She's been out in the open ocean, possibly exposed to higher levels of Bg bacteria than your animals here."

"Wait a minute," Dulcie said. Her skin buzzed. "There's another piece to this puzzle. Didn't you say that erectile function is voluntary, like breathing?"

Fox nodded.

"And isn't it possible that these chemicals, these soporifics, inhibit a male dolphin's ability to maintain an erection, since it is a conscious, voluntary act?"

"No pregnancies," Fox muttered.

Dulcie closed her eyes. "Double whammy. Russian roulette with falling

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asleep, and if that wasn't bad enough, they can't breed."

"Surely this couldn't be true across the board," Pangborn said. "In any population, there would be a bell curve of effects. Even if these chemicals are affecting the majority of cetacean populations, there have to be some immune animals."

"Maybe not enough," Fox said. "Maybe they can't adapt fast enough to deal with the increasing levels of Bg bacteria."

"Especially in conjunction with toxins and diseases that have already weakened their immune systems," Dulcie said. "We've been poisoning the oceans for years."

Pangborn rolled his eyes.

"It's true," she insisted. "Lieutenant Fox can tell you that necropsies show increasing levels of heavy metals and toxins, not just in cetaceans, but in all ocean life. My God, how desperate they must be—they're dying randomly, and they can't have babies. This must have been building for years, until it got to such a catastrophic level that they had to take action."

"And they believe we're responsible," Fox said. "Which is fair enough, really."

Dulcie said, "And they also think that evicting us from their territory will fix everything, which it won't. They're just trying to find a solution to a crisis they have no way of comprehending."

"You know," Fox said, "if all this is true, and they're suffering the effects of being constantly oversedated, then maybe we can counteract the effects with stimulants."

Dulcie snorted. "Dolphins on speed."

"Or caffeine. Or even epinephrine. Anything that would allow them to breed, at least."

"How could we possibly make enough?" Dulcie asked. "The oceans are huge. There are millions of cetaceans, and they all need help *now*. It probably took several years for the bacteria to build to such a lethal level."

"We may not need as long to repair the damage."

"All this is moot if we can't get them to stop attacking us," Pangborn said. "They won't live long enough to see a cure. Doctor Huber, we should discuss ways to explain to your dolphins that we understand the problem, and we can help them, but only if they stop trying to evict us from the ocean. If we don't find a way to get that message into the wild populations soon, it will be too late."

"I'll head back to the med lab and see if I can't argue them into some more tests," Fox said. "We need more to go on than conjecture. I'll get algae and seaweed samples to start with, see if I can find or breed some live *Bacillus granieri* in them."

"I don't like it," Dulcie said.

Pangborn took a moment before he responded. As always, his tone was even. "This is the message that we have to deliver. This comes from the Office of the Chief of Naval Operations. We are in the power position, and we have to make it clear that we won't be pushed around."

"But threats?"

"Not threats. All we're doing is offering to help, contingent on their ceasing their attacks. We need to frame the offer in a positive way, while still maintaining a solid position."

Dulcie looked down at the paper in front of her, which was covered with scribbles and crossed-out phrases.

"You think they'll understand?"

She rubbed the creases in her forehead. "I don't know. These words on the buttons—they're just our version of what we're trying to say. We don't know how dolphins conceptualize the words. Maybe SICK to us is DYING to them. Maybe HEAL to us means UNPLEASANT VET VISIT to them. Maybe they can't get the idea of negotiation. Maybe they won't get OR as cause-and-effect, just as choices."

With the look of a man whose patience has been sorely tried for many

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days, Pangborn said, "We have to do something. I'm due to report back to my office by seventeen hundred hours today. That's two hours from now."

"And here we are again," Dulcie said, staring at Misty through the tank window. The dolphin floated in front of the keyboard, waiting.

"We ready?" Ian asked.

"Sure." She glanced at Pangborn, who remained impassive. "Be sure to give her plenty of fish as we go. We'll start with MISTY REPORT: DOLPHINS WANT PEOPLE OUT."

Misty hit "YES YES."

"MISTY REPORT: DOLPHINS WANT DOLPHINS SICK NOT." *Dolphins don't want to be sick.*

Misty jerked back in surprise. Cautiously, she pressed "YES."

"Does she understand?" Pangborn asked.

"We'd better hope so," Dulcie said. "Ian, try PEOPLE WANT HEAL DOLPHINS, AND, PEOPLE OUT NOT." *We want to help you, but we aren't leaving the water.*

Misty squawked. Her eyes bugged out.

"UNDERSTAND?"

The dolphin just floated.

"I think she's confused," Ian said.

"Let's try it another way. DOLPHINS PUSH PEOPLE OUT NOT, AND, PEOPLE HEAL DOLPHINS. UNDERSTAND?" *We'll help you if you stop trying to push us out of the water.*

Still she just floated.

"We're really pushing the grammar and vocabulary." Ian seemed tense. "She may not be able to stretch this far."

"Try this," Dulcie said. "DOLPHINS PUSH PEOPLE OUT, AND, PEOPLE HEAL DOLPHINS NOT. LATER, DOLPHINS SICK MORE. UNDERSTAND?" *If you keep pushing us out, we won't help you, and you'll just get sicker.*

Misty moved forward. "DOLPHINS SICK."

"Give her some fish. Now, DOLPHINS PUSH PEOPLE OUT NOT."

She squawked and hit "NO NO PEOPLE OUT."

"Can we explain to her that people's presence in the water isn't what's making dolphins sick?" Ian mused.

"We can try." Dulcie thought, then murmured, "PEOPLE IN, AND, DOLPHINS SICK NOT. DOLPHINS PUSH PEOPLE OUT NOW, AND, DOLPHINS SICK LATER." *Our being in the water isn't making you sick. And even if you push us out, you'll still be sick.*

Misty's eyes widened, a sign of stress and surprise.

"DOLPHINS PUSH PEOPLE OUT NOT NOW," Dulcie said. "PEOPLE HEAL DOLPHINS LATER. UNDERSTAND?"

Misty slapped her tail on the water's surface.

"She's agitated," Ian said.

"UNDERSTAND?" Dulcie repeated.

Reluctantly, Misty touched, "YES PEOPLE OUT PEOPLE OUT."

"She understands," Ian said, "but I don't think she agrees to the terms."

"Tell her that we're not going anywhere," Pangborn said. "Tell her that no matter what, we won't leave the water."

"Admiral, I—"

"Just do it. We're running out of time."

Dulcie's eyes narrowed. "PEOPLE OUT NOT," she said. "DOLPHINS PUSH PEOPLE OUT, AND, PEOPLE OUT NOT."

Misty clapped her jaws.

"DOLPHINS HIT PEOPLE, AND, PEOPLE OUT NOT," Dulcie said. "DOLPHINS WANT PEOPLE OUT, AND, PEOPLE OUT NOT. Ian, clear the board. Now hit PEOPLE OUT NOT. FINAL ANSWER."

Misty rammed the keyboard, almost breaking the "NO" button.

"DOLPHINS PUSH PEOPLE OUT NOT, AND, PEOPLE HEAL DOLPHINS. UNDERSTAND?" *If you stop attacking us, we'll help you.*

Rolling an eye at the keyboard, Misty sank to the bottom of the tank.

"She's really upset," Ian said.

"I don't blame her," Dulcie said. "Try DOLPHINS PUSH PEOPLE OUT NOT,

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AND, DOLPHINS BABY LATER. MISTY BABY LATER."

"But she can't see the keyboard," Pangborn said.

"She can hear it. Each button has a corresponding sound, remember?"

Ian hit the keys.

Misty came to the surface slowly, and exhaled explosively. "BABY LATER QUESTION."

Dulcie's spine melted in relief. "YES. Give her some fish."

Misty ignored the fish. "MISTY WANT PEOPLE OUT."

"PEOPLE OUT NOT. FINAL ANSWER."

Misty floated backwards slowly.

"I think she understands," Dulcie said.

"We have to see if she can transmit that message to other dolphins," Pangborn said.

"I'll go to Sport's tank," Dulcie said. "When I give the signal, key in MISTY TELL SPORT REPEAT: PEOPLE OUT NOT. PEOPLE HEAL DOLPHINS. Then we'll have Sport report on what Misty told him." She got in place at the keyboard by Sport's tank and signaled Ian, who hit the keys.

Misty slowly swam to the gate between the tanks and exchanged lengthy vocalizations with Sport, ending by clapping her jaws at him. He retreated toward his keyboard.

Wide-eyed, he jabbed at the keyboard. "PEOPLE OUT NOT. PEOPLE HEAL DOLPHINS."

"On the first try," Dulcie muttered. She blew her dog-whistle and tossed him a few fish.

"Good," Pangborn said. "Very good. Now we just need to get them to transmit that message to wild cetaceans."

"How are you going to do that?" Dulcie asked with a frown. "Your messenger dolphin died." She saw the look on his face and stood abruptly. "Oh, no. Not a chance."

"Doctor Huber, if I don't have substantial results for my superiors, today, then hundreds of whales and dolphins will be dead by this time tomorrow. By next week, hundreds of thousands. By next month, all of them. Do you want that to happen?"

"You're not taking my dolphins anywhere," Dulcie said, eyes narrowed.

"It's a short trip," he said. "A half-hour at most. All we need to do is get them into the Naval sea-pens on the coast and have them transmit their message. It's the only way. We haven't been able to collect any additional wild dolphins. And our time has just about run out."

"No."

"Actually, it might work out better this way. We can bring the keyboards with us and maybe even be able to negotiate right there on the coast. Your dolphins will be back here before dark. Now, how long will it take to drain the tank?"

"Aren't you listening to me? I said no!"

"It's not much of a risk to your animals," he said. "And it could be the deciding factor between peace and military retaliation against cetaceans. Can you really look yourself in the mirror if you condemn every living whale to death?"

Dulcie opened her mouth, but nothing came out. He was right, and she hated him for it. "One dolphin. You can take one."

He weighed his choices, then nodded. "All right. One. But that one has to be Misty."

"I know," Dulcie said, despising him, and hating herself even more.

Within the hour, Misty was loaded onto a military truck, Dulcie by her side.

"I'm sorry, hon," Dulcie said, her heart breaking. "It won't take long. Just think of all the good you'll be doing."

Thick tears leaked from Misty's eyes. Repeating her distress whistle softly, she hung limp in the dolphin transport.

Dulcie wanted badly to hug Misty, to reassure her, but she wasn't sure her touch would be welcome. Tentatively, she laid her hand on Misty's side. The dolphin flinched. Dulcie pulled back, fighting tears.

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The sea-pens were on a rocky coastline, inside a naval base. Dulcie ignored the scenery and concentrated on hosing Misty down, keeping her skin wet and cool.

The truck stopped.

"We're here," Fox said, peeking in the back. "Just need to unload her and get the keyboards set up."

Dulcie hid her face. "Yeah. Whatever." Numbly, she climbed out of the truck and watched the Navy guards efficiently pull Misty out and carry her along a wide wooden pier beside fenced-in sections of shallows. They slid her into the water carefully.

Dulcie hurried over to make sure Misty was all right. The dolphin swam around the fenced enclosure, baffled and uncertain.

"She hasn't seen the ocean in decades," Dulcie said, to no one in particular. "I don't know if she even remembers it."

"She'll be all right," Fox said.

Before Dulcie knew it, the large keyboard had been lowered into the water, hanging from the pier, and the smaller one was set up under a Plexiglas shield on the pier.

"Doctor Huber," Pangborn called. "We need you over here."

Dulcie forced herself to walk over to the keyboard. A metal bucket of fish sat beside the chair. Automatically, she said, "We should offer her some fish. Start with something positive."

He nodded.

"MISTY WANT FISH QUESTION," Dulcie keyed.

At the familiar sounds, Misty jerked. She looked at the keyboard in the water.

"She's probably in shock," Dulcie whispered. "I'll try again. MISTY WANT FISH QUESTION."

Misty cocked an eye at her, then hit "YES."

Dulcie dumped in a handful of herring, but Misty ignored them. The fish sank to the bottom, lost between the rocks.

"MISTY SQUIRT," Dulcie keyed.

Automatically, Misty took a mouthful of water and sent a small spray in front of her.

Dulcie blew her whistle and tossed in another couple of herring. Misty mouthed them but let them drop.

"We should move on," Fox said quietly. "Keep her distracted, keep her attention on the keyboard while we have her."

Pangborn nodded. "Go ahead, Doctor. Give her the instruction again."

Dulcie keyed, "DOLPHINS PUSH PEOPLE OUT NOT, AND, DOLPHINS BABY LATER. MISTY BABY LATER."

Misty just floated there, watching her.

"DOLPHINS PUSH PEOPLE OUT NOT, AND, DOLPHINS BABY LATER. MISTY BABY LATER. UNDERSTAND?"

Misty nudged the "YES" button.

"Launch the boat," Pangborn said. Six Navy staff took an old beat-up rowboat weighed down with sacks of sand, and pushed it into the water, playing out the line as it drifted further out.

"Why?" Dulcie asked.

Pangborn said, "To attract their attention. They don't let boats go far unmolested."

"Look," Fox said, pointing out to sea.

A half-dozen common dolphins, their sides patched with gray and white, broke the surface in unison as they leaped into the air a few hundred feet out into the ocean. They swam straight for the rowboat.

"We have our audience," Fox said.

"MISTY TELL DOLPHINS: DOLPHINS PUSH PEOPLE OUT NOT, AND, DOLPHINS BABY LATER. MISTY BABY LATER."

Misty ducked her head underwater. She vocalized loudly, in chirrups, buzzes, and whistles.

The common dolphins slowed down, then veered from the rowboat and swam closer to the sea-pen's fencing. They clapped their jaws underwater, vocalizing back furiously.

"Make sure they understand that us

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leaving the water won't fix their problems."

"MISTY TELL DOLPHINS: PEOPLE IN NOT, AND, DOLPHINS HEAL NOT."

"Try another one," Pangborn said. "Make it clear that they need our help, and that we're not leaving the water."

"MISTY TELL DOLPHINS: PEOPLE HEAL DOLPHINS. PEOPLE OUT NOT."

Misty and the wild dolphins continued vocalizing for a long time. Finally, the common dolphins drifted away.

"How will they get the message to the rest of their troops?" Dulcie asked.

Pangborn shrugged. "In whatever way the message of war was disseminated. There must be a communication mechanism."

"MISTY DESCRIBE," Dulcie keyed.

Slowly, Misty floated back to the keyboard. "MISTY SWIM."

"MISTY DESCRIBE BEFORE."

"MISTY TELL DOLPHINS PEOPLE HEAL DOLPHINS DOLPHINS BABY LATER." A moment later, "MISTY TELL DOLPHINS PEOPLE OUT NOT."

Dulcie tossed in some more herring. Misty just watched as they settled onto the rocks below.

To Dulcie's surprise, the Navy staff were able to recapture Misty without a fuss. An hour later, she was back in her own tank. She drifted around the water, hardly moving. From time to time, she sent out a plaintive distress whistle.

"She's exhausted," Fox said. "She's had a very busy day."

"No kidding," Dulcie said, rubbing her brow in the hopes of relieving the headache that was building there.

"That's all we can do for now," Pangborn said. "I've apprised my superiors of what we've done. Now we wait." He hesitated. "Doctor Huber, I want to thank you for your cooperation. You've done a great service for your country. I hope that the work we've done allows us to avoid any further violence."

"Me too," she said, staring at Misty.

"The Office of the Chief of Naval Operations is impressed with what we've accomplished in such a short period of time. They have agreed to wait forty-eight hours before launching an offensive. If the attacks diminish sufficiently before then, we will have done our job."

Dulcie nodded, unable to focus her thoughts. "That's good."

"Doctor," Fox said, "I'd like to suggest that you spike the evening feed with some kind of stimulant." He held up a large bottle of time-release caffeine pills. "It's a place to start."

"Thanks," Dulcie said, taking the bottle. "I'll think about it."

"Sir," Fox said softly, "maybe we should leave now. We can check back in the morning."

"We'll be back at seven A.M.," Pangborn said. "Good night, Doctor."

"Good night," Fox echoed.

She nodded and waved, unable to form words.

After a while, she realized it had grown dark, and she was shivering. She still held the bottle of pills in her hand.

She found Ian in the fish-room, sorting fish for the evening feed. She set the bottle on the counter. "Each dolphin gets a half-pill," she said in a monotone. "To be on the safe side."

"You all right? How'd it go at the Naval base?"

"It went fine. I just need some rest."

"Go on home," Ian said. "I'll take care of things here. Don't worry."

As Dulcie passed by Misty's tank, she saw the dolphin watching. She crouched down and pressed her hand against the thick Plexiglas.

"Will you ever forgive me?" she whispered.

Misty went to the underwater keyboard. Dulcie automatically went to the smaller keyboard, lit by the lab's floodlights.

"ALL DONE," Misty keyed, her traditional end-of-day farewell.

Dulcie started sniffling. "ALL DONE." She left before she started sobbing in earnest.

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That night, Dulcie dreamed she was walking along the beach. The surf rolled in slow and green-gray under a shadowed sky.

A wave built, far out to sea, a dark wave capped with foam. It drove closer, grew taller, seethed with movement.

In the dream, her knees buckled. She collapsed onto the sand.

Bodies shot out of the water, onto the shore—dozens, hundreds, thousands of bodies of different sizes, shapes, colors. Whales, dolphins, porpoises, all drove up onto the beach, piling themselves layer upon layer, struggling to push themselves out further, and still they came, filling the beach as far as she could see with writhing forms, crushed by the weight on top of them.

Dulcie woke, skin buzzing with shock and disbelief. *Just a dream,* she told herself. She wrestled out of the sodden bedclothes and stumbled into the kitchen for a glass of water.

It was early, but her nightmare spooked her from going back to sleep. She meandered through the morning, eating breakfast, taking a shower so hot her skin kept sweating for ten minutes after she got out, filling her head with music, television, ideas for extending the keyboard research so they could keep communicating with the wild cetaceans, in case yesterday's message didn't get through.

At one point, she found herself sitting at the table, shoulders heavy, holding a hot mug of strong black tea, wondering what would happen now. She wanted to tell her friends at other facilities what was going on here, get them to spread the word, post this nasty secret on online bulletin boards, get a public uproar going to force the government to do everything it could—but there was that NDA she'd signed. She didn't want to find out what military prisons were like.

She pulled up to the dolphin lab at around 7:00, on a bright but hazy morning. Military vehicles told her that Pangborn and Fox were already there.

When she opened the door and walked in, the first thing that struck her was stillness. No groggy, chatting volunteers or interns, no bustling around with research equipment.

Ian, Fox, and Pangborn sat on a bench near the tanks, talking quietly. Ian's fair skin was flushed, especially around his eyes. Fox's face looked dark and angry. Pangborn looked the same as always.

On hearing her come in, Ian looked up. "Dulcie . . ." he said, but he couldn't go on.

Ice fingers walked up her spine. "What?" she asked. "What happened?"

"I'm sorry," Fox said. He glanced at the tanks. "We just got here, but—well, it's already too late."

Dulcie rushed over to tankside. The tanks were being drained and were now only three feet deep. Three dolphins had been gated into the nearest tank: Misty and Hannah, supporting Sport's lax body.

A soft, continuous distress whistle filled Dulcie's ears.

"No," Dulcie said, or tried to. She couldn't breathe. She glared at Fox. "Why didn't you get him out? Jesus, we have to get him—"

"Dulcie," Fox said. "It's too late. Look at his eyes."

She looked in, saw Sport's brown eyes, open, vacant, filmed. His mouth was lax, his pink tongue sliding out one side. "But how? We gave them those caffeine pills last night! They should have been OK!"

"He's young," Fox said. "He got tranquilized yesterday, got hit with a stimulant, then more drugged fish and another stimulant. Maybe it was just more than his system could take. Won't know for sure until we do a necropsy. Maybe not even then."

"They won't let us in anyway," Ian said, his lip twitching. "That's why we're draining the tanks."

Instinct pushed her to tankside, reaching one knee up onto the thick blue

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wall. Hannah rolled a wide eye, streaming with thick secretions, and squawked. Dulcie stopped, remembering what had happened last time she'd gotten in.

"Oh, Misty," she murmured.

There was no oxygen in the air. Her legs felt starved for blood. She stumbled over to the keyboard, tapped at it: "REQUEST PERSON IN."

Hannah squawked. Misty clapped her jaws. It took Dulcie a moment to realize Misty was jaw-clapping at Hannah and not at her.

"REQUEST DULCIE IN," she keyed in, waiting for one of the dolphins to ram the "NO" button. They didn't.

Slowly, cautiously, she levered one leg into the water. Hannah's eyes bugged out, but she didn't charge.

"Misty," Dulcie said, moving toward them, grateful for the water's support, unsure how much longer she could carry all her own weight. Her sodden shorts swirled around her thighs.

Fox came up to tankside, rested his elbows on the broad concrete wall. "Doctor Huber—I want you to know that the attacks are already tapering off. It seems we have a truce."

Dulcie stared down at Sport, the sleek gray skin. Dolphins looked almost the same dead as alive, their streamlined bodies and firm skin retaining their shape after death. Years ago, she'd watched a newborn calf die minutes after birth, and hadn't been able to pinpoint the moment of passing.

Fox said, "Admiral Pangborn and I have been working over possibilities for dealing with the Bg bacteria problem. We've got some proposals worked out, short-term and long-term."

Misty seemed so still, except for that plaintive whistle. Dolphins seemed to grieve differently from people—no railing, no wailing, just this soft whistle, this slow swimming. As if more bewildered and confused than angry.

Fox said, "We figure that if we can show the wild cetaceans a pregnant female dolphin, that'll buy us—"

"Fox," Pangborn said, looking at Dulcie.

Fox shut up.

Dulcie reached over Misty and laid her hand on Sport's side, feeling the shallow, minute striations, like grooves on a record. Cool, now.

She walked along with Misty and Hannah as they drifted forward with slow movements of their tails, bearing the cold weight between them. Anger built inside her. She wanted to smash the walls of the tank. She wanted to shove Pangborn's face in, shout at him, make it all his fault. The anger cleared her mind, brought her thoughts into crystal focus.

"Doctor," Pangborn said, "Your work will save a lot of other lives. Shame we couldn't save this one too."

So many more will die no matter what, she thought. *Maybe even whole species.*

Pangborn said, "I want you to know that we're going to do all we can, given our resource constraints. For the rest."

She frowned. "Resource constraints? Aren't you throwing everything you've got at this?"

Pangborn and Fox exchanged a glance. "Cost-benefit analysis," Pangborn said. "I had to convince my superiors that this approach would be substantially less costly than an all-out attack. Now I've got to make sure it stays that way—or else we'll go back to the original plan. Realistically, there's only so much we can spend on this issue. It's not the only thing the Navy has to worry about. But we *will* do everything we can."

Water sloshed over her hand, over Sport's corpse. She realized she no longer cared about the NDA. "Yes," she said, meeting Pangborn's eyes. "Yes, you will."

She had to get out, dry off, get to work. But it took all her strength to stop and let the dolphins move away from her. Her fingers trailed along Sport's sleek, still body, holding on until the very last moment, until he slipped from her hands. ■

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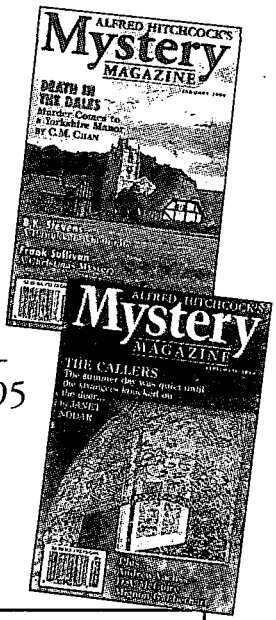

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THE REFERENCE LIBRARY Tom Easton

Probability Sun, Nancy Kress, TOR, $24.95, 348 pp. (ISBN: 0-312-87407-3).

J, William Sanders, iPublish, $17.95 (e-book: $3.95), 322 pp. (ISBN: 0759550123).

To Leuchars, Rick Wilber, Wildside, $14.95, 114 pp. (ISBN: 1-58715-256-8).

The Leaky Establishment, David Langford, Big Engine (P.O. Box 185, Abingdon, OX14 1GR, UK; www.bigengine.co.uk), £7.99, 218 pp. (ISBN: 1-903468-00-0).

The Dragon Seekers: How an Extraordinary Circle of Fossilists Discovered the Dinosaurs and Paved the Way for Darwin, Christopher McGowan, Perseus, $26, 254 + xvi pp. (ISBN: 0-7382-0282-7).

Body Bazaar: The Market for Human Tissue in the Biotechnology Age, Lori Andrews and Dorothy Nelkin, Crown, $24, 246 + x (ISBN: 0-609-60540-2).

The Art of Richard Powers, Jane Frank, Paper Tiger, $29.95, 128 pp. (ISBN: 1-85585-890-8).

In *Probability Moon* (reviewed here in October 2000), Nancy Kress gave us the tale of a distant world inhabited by people who got vicious headaches whenever they violated "shared reality," or the consensus of opinion and convention. No one was capable of thinking an original thought, but the residents of World were a peaceful sort, at least until the humans arrived, exploring a Universe opened to them by the space gates left behind by an unknown elder race and hunting for a solution to the Fallers, a species that attacks on sight, as if it cannot abide the thought of sharing the Universe with any other intelligence, and refuses to talk (prisoners even commit suicide at the very first opportunity).

Because the people of World pose an intriguing puzzle, human anthropologists soon arrived. Because World had seven moons, and one is a huge artifact apparently left behind by the builders of the space gates, so did military investigators.

The anthropologists promptly ran into a problem: Because humans do not always agree with each other (or, of course, the Worlders), they do not "share reality." The Worlders therefore assigned one of their own who had shown a talent for initiative and was therefore "unreal," Enli, to mediate. After the inevitable contretemps, they declared humans unreal too, and the visitors were on the run into the sacred mountains, where they found a mystery clearly related to the artifact moon.

Meanwhile, the military researchers were pushing buttons on that moon. When a Faller craft popped out of the local space gate, they discovered the moon was both a defense and a weapon. Unfortunately, they then managed to destroy the moon.

Exeunt humans—until now, when we see the sequel, **Probability Sun**. Many of the same characters are back, with the addition of Tom Capelo, a genius physicist rendered half-mad when the Fallers killed his wife. He hates the alien foe with a dreadful passion and is eager to find a way to defeat the shield

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they have deployed to protect their warcraft from all attack. Marbet Grant is a gengineered empath extraordinarily sensitive to the nuances of others' body language. Lyle Kaufman is their shepherd, assigned to coordinate Tom's efforts to figure out what the artifact buried in the mountains is and what it can do and Marbet's efforts to interrogate the only live Faller ever captured. He also has to keep the Faller's presence on the ship secret, especially from the potentially murderous physicist.

He also has to face a profound ethical question—though as a military man, he has little choice about the answer he must find—when the mountain artifact turns out to be much like the lost moon. It—and the Faller!—soon leads Capelo to theoretical insights that may hold the keys to the mysteries of the star gates. It can be a shield for a ship, a planet, or a solar system. It can also be a weapon, capable of destroying a ship, a planet, or a solar system. *And* it emanates a field that affects Worlder brains and is responsible for the "shared reality" phenomenon.

Because it's a weapon and a shield, it is inevitable that the humans will remove the artifact, hauling it off to serve their own vital purposes. But that will mean World's idyllic "shared reality" will be threatened. Worlders will be free to think for themselves, and though a few may think this is a nifty change, some will inevitably turn greedy, selfish, and violent. In other words, they'll be just like humans, and they will have to develop ways to live together in relative peace just as we have.

Given Kress's record, it is no surprise that *Probability Sun* is very readable, very convincing, and sure to appear on award ballots. Yet I must temper my recommendation with the thought that even though the philosophy is intriguing, I do not think that "shared reality" would crumble nearly as easily as Kress insists. Her Worlders have grown up with instant aversive conditioning to avoid independent thoughts; they should therefore be quite incapable of antisocial action. But she is saying, in effect, that if only the externally imposed lid of social (or superscience brain field) restraint is removed, many of us must revert to our basic human (Worlder) nature as greedy, selfish, and violent beings. However, modern psychology, though it admits the presence of initial tendencies, would have it that those tendencies almost always are overridden by rearing, education, and even the habits inculcated by life under social restraints. History shows societies descending into chaos when a tyrant is removed, but I think that happens only when there are severe shortages of vital resources such as food, or threats from competing political groups, and people must suddenly look after themselves as best they can. On World, there are no resource shortages, the benign government is intact, and there are no competing politicians or warlords. I would expect the transition to be much more gradual.

That said, Kress has produced a worthy sequel to *Probability Moon*, a fine read, and, yes, a provocative book. Enjoy.

William Sanders has in J what could prove to be the beginning of an excellent series. The tale opens with a sad letter from an editor to an agent about a writer named Jay, who has taken up drinking and whose work just doesn't have what it takes anymore.

Scene two: Ann, a physicist, is in a psychiatric hospital where her doctor has about given up. He's tried everything, nothing works, and she still wakes screaming in the night, but wait! Here's a nifty new drug, Lomazine, if she'll just try it.

Well, what the heck, why not? So off she goes to the special care wing, where the staff tend to be those misfits no one else will have. The nurse promptly gives her an overdose of the drug, and when she wakes thirsty in the middle of the

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night and leaves her room in search of water, she runs into Duncan Brady, an orderly with flat, pale eyes and a mean streak a mile wide.

As Brady starts to sodomize her, Jack—a lesbian gunslinger from a world in post-holocaust ruins—materializes, analyzes the situation, and promptly blows a suitable hole in him.

Oops! Can't have that! No one would ever understand! So Ann and Jack are on the run. They hole up in a sleazy motel, discover that they make great lovers, and then . . . What's your name, sweetheart? Jacqueline Ann Younger, of course. Me, too! And they just have time to compare their identical fingerprints before the cops show up and throw a stun grenade through the door.

So the motel room's a wreck. But now so's the town outside, which Jack recognizes as home. If the reader hasn't twigged yet, this should do it. Sanders is playing alternate worlds games, with the corresponding versions of Jack/Ann getting a chance to play games with each other.

So who are the two strange guys in silver suits, carrying funny-looking guns and demanding Ann, dead or alive? Never mind. They're on the run again and tumbling out of the air in front of Jay (the writer, and of course her complete name is also Jacqueline Ann Younger), who was just about to pull the trigger and End It All. More introductions are in order, more puzzlements, and soon it is clear that whatever is going on, it's working out nicely in one way: all three had been hearing voices, sleeping badly, and drinking or pilling to turn it all off. But now they're feeling better, as if the whole problem had been pieces of each other leaking across the parallel-world divide. And the Indian college student who was Jay's gofer is now saying that his Wise Old Indian grandpa knows something relevant and can help.

If they can ever get to him, for here come those cowboys in the silver suits again! They just can't be stopped. Bullets bounce, wild dogs die, and when Jack arranges for their car to take a dive off a high cliff, they come back like their papa was Wile E. Coyote.

What is going on? It all comes clear in the end, but not even the guys in the silver suits will get me to say how.

Except . . . I'm waiting for the sequel, when three lovely identical agents of the Imperium stumble upon nefarious doings and save the multiverse.

Buy this one, folks. Sanders knows how to plot, how to put believable, sympathetic characters on the page, and how to laugh. You'll have fun.

Rick Wilber's **To Leuchars** pulls together three *Asimov's* stories with new material to tell us of what happens when the S'hudonni come to Earth. The S'hudonni are well-armed, semi-aquatic merchants with the kind of patronizing attitude that should ring bells aplenty for any reader with a sense of human history. The tale opens on a Florida beach, where Peter Holman, a moderately talented and ambitious reporter, is waiting with his brother Tom for a project to come to fruition. Tom is a bioengineer who has tinkered with the genes of endangered sea turtles to make them home to a new beach; he had released 94 of them; now he is waiting for just a few—maybe!—to arrive on schedule and justify his life.

The S'hudonni had been orbiting silently for months. Peter catches the news that the ships have vanished. And then the first turtles show up—one, two, a dozen, dozens, boiling out of the sea in numbers far beyond Tom's wildest hopes—followed by the alien Twoclicks with the word that, "Oh, yes, we have manipulated them, the turtles. Their species is saved now, yess?"

Poor Tom. Poor Peter, too, for he is feeling guilty about having bedded Tom's girlfriend just before she vanished, and now she's back, turning out to be an alien data- and seed-gathering construct, and Peter has a new job,

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demonstrating human mating practices for the edification of academics and rubes across the galaxy.

Tom will become a bomb-throwing resistance fighter and die. The US will try to battle the might of Imperian S'hudon and be turned into a continental grain farm. Peter will return from the stars, change his name, and become an English prof and minor poet. In due time, he will go to Leuchars, the sole city on Earth's sole colony world, a gift of the S'hudonni, encounter a new rebellion, and redeem himself.

Not a big book, but a warm, sympathetic, thoughtful one, well worth its price.

David Langford's **The Leaky Establishment** first appeared in 1984, but remains perfectly timely, what with all the fuss in the last year or so about sloppy security at Los Alamos.

As you might expect of any book with an introduction by Terry Pratchett, the mode is humor, but there is a serious side as well. Langford once worked in a nuclear research establishment and claims that the cavalier attitudes of his fictional researchers and the malign stupidity of his representatives of Management and Security are spot on.

The tale begins when young Llewellyn walks into Roy Tappen's office dangling a string bag containing a plutonium "pit," or bomb core, from one hand. "Want to go for a beer?" he carols, as he sets the pit carefully in the wastebasket.

"Why not?" and off they go to bemoan the laxness of security and challenge each other to steal a filing cabinet under the guardians' noses. They succeed too, and then Roy discovers the pit in one of the cabinet's drawers, along with a note from the janitor tsking that heavy items don't belong in office wastebaskets.

Roy feels the next step is obvious: He has to get the bloody thing back where it belongs! His wife insists; in fact, she is moving out until he does just that. Unfortunately, Security has chosen this awkward moment to beef up its procedures. And the loony coworker next door—he of the backyard bomb shelter, the homemade booze, and the Rube Goldberg home energy system—shows up with a radiation detector to say, "Gee, y'know, there's a hot spot in your house . . ."

It's a comedy of errors in a classic British mode. It's a satire that pokes fun at incompetent functionaries. But it also casts a very chilly eye on technical experts who get so used to dealing with very dangerous materials that they neglect reasonable precautions and, indeed, get extraordinarily reckless. As Langford has Llewellyn and Tappen say at the end:

"Gawd. How d'you keep grinning, knowing all the things you know?"

"Effortlessly. It's what we aged and cynical scientists learn to do all the time."

Or, as Security might say: "It's a darned good thing someone is keeping an eye on these blighters!"

If you can find or order a copy, you'll enjoy it.

Ancient bones aren't as scary as plutonium pits, but the people who study the two things are just as human, as Christopher McGowan makes very clear in **The Dragon Seekers**.

The scene is early nineteenth-century England, a few decades before Darwin published *On the Origin of Species*. The church rules, anyone guilty of evolutionary (or "transformational") thought is judged a heretic, and there isn't even a word for dinosaur. But quarry-workers and beach-combers are finding curiosities, and academics such as William Buckland, Gideon Mantell, and Thomas Hawkins are paying attention, collecting samples, and doing their best to make sense of them all as ichthyosaurs, plesiosaurs, iguanodons, and more. The humanity of these folks shows in a number of ways. Hawkins, for instance, grew in-

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famous for his habit of touching up fossils with carefully painted plaster to "improve" them. And hardly anyone gave proper due to Mary Anning, the working class woman who made her living by combing the cliffs of Lyme Regis for fossils she could sell, studied everything she could, and knew as much as or more than any of the academics.

Sell? Well, there's a human touch here too, and it's one that has made the news in recent years as paleontologists argue over whether commercial collectors have any place in the field. The academics insist that commercial collecting destroys scientific value and credibility; the collectors say that without their crassly motivated efforts, many fossils would never be found or saved from destruction. And in Anning's day, the fossils embedded in the stone of a quarry being mined for road fill were routinely pounded into gravel along with the stone until the collectors showed up, ready to pay good coin for these curiously shaped and stained pieces of rock. In other words, money was there at the start, rescuing the fossils so they could be studied and identified.

And so the academics could write books and give lectures that drew large and interested audiences. The ancient bones enchanted people then just as they do now, and they taught important lessons: the world was not always as it is now, different beings lived here once, life changed, and changed again, and perhaps there was some sort of sequence to it all (though the academics debated this quite fiercely).

This is what was in the air in Darwin's time just a little later. It shaped his own thinking, and it prepared the ground for the seed he would sow in his own turn. Without the fossils, Darwin might not have reached his famous conclusions, or they might have been rejected out of hand.

Since evolution by means of natural selection is now recognized as the key organizing principle of the life sciences, we can credit those early fossil hunters with laying the groundwork for a great deal of modern science and the current boom in biotechnology.

McGowan doesn't push things quite that far. He sticks with the fossils and the personalities involved in the birth of paleontology (his own field), and he makes a very readable, entertaining story of the history.

Recommended.

In recent years, biomedical researchers have found a great many ways to use human genes, organs, cells, and the substances they produce, to save lives. They have obtained patents on their discoveries, and they have founded businesses to meet health-care needs and—not at all coincidentally—to make money.

Some ethicists find this a very awkward situation. In **Body Bazaar: The Market for Human Tissue in the Biotechnology Age**, Lori Andrews and Dorothy Nelkin examine a number of cases that have arisen—cancer patients whose tissues have, without their knowledge or consent, been turned into marketable products; indigenous peoples whose blood has been sampled in search of clues to heritable diseases; DNA ID schemes; the sale of human eggs, embryos, and organs; and more. They note that such activities often clash with prevailing social values and that in the past we have tried to keep the human body "sequestered from the market" by treating blood and organs as things to be donated, not sold (the Uniform Anatomical Gift Act). Do we need new laws to lay similar strictures on the new products? Without them, we run the risk of turning "people into the marketable products of a body bazaar."

Is a "body bazaar" bad? Perhaps not, if you have control, but I would hate to use my heart as collateral for a loan—and then have the bank able to foreclose! Nor would I care to see something derived from my body on the

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market—at least, without getting a cut.

Do such ideas sound a bit science-fictional? Then you can see why I mention the book here. The discussion is one that everyone should be paying attention to, but *Analog* readers may be particularly receptive.

Science fiction book cover art has had a number of distinctive styles, each identified with a particular artist. Frank R. Paul was an early star. Kelly Freas came later and remains popular. Richard Powers began to appear on covers in the fifties, was omnipresent in the sixties, and is now so passé that his name is mentioned only as an emblem of a bygone and unmissed era.

Yet his artwork was and remains as evocative of the spirit of SF as anything before or since. Powers did not try to portray alien scenes or gleaming spaceships in meticulous detail. His models were surrealists such as Miró and Tanguy. His forms were organic, impressionistic blobs and swirls, occasionally framing realistic faces or objects but always leading the eye and mind down a path of wonder.

If you don't have some of those old paperbacks on your shelves, get a copy of **The Art of Richard Powers**. Jane Frank has assembled an excellent survey of Powers's work, complete with a charming and readable biography by his son Richard Gid Powers and a hitherto unpublished interview with the artist.□

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BRASS TACKS

Dear Sirs,

Tom Easton's recent commentary from your July '01 issue "The Reference Library," from my perspective as a computer scientist and molecular biologist, leaves much to be desired.

In response to his comment: "Is the fuss justified? Are eentsy-weentsy teeny-tiny machines really going to solve all conceivable resource shortages and give everyone access to all the consumer goodies they can dream of?," I would have to respond, "When we figure out how to build them, the answer will most certainly be yes."

First, it would appear that Tom cannot differentiate between micrometer scale devices (those discussed in the *Science News* article that he uses to dis nanotechnology) and nanometer scale devices such as all of the proteins that make up the complex nanosystem known as "Tom Easton". One big problem that MEMS (micrometer scale) devices have is "stiction" caused by small dust particles that cause stickiness between adjacent surfaces. This problem disappears entirely at the nanoscale when you have atomically "perfect" structures. A little investigation by Tom would have shown that scientists at Berkely have actually demonstrated nested carbon nanotubes that can function as essentially "frictionless" bearings as predicted by Drexler in Nanosystems.

I recently presented a business plan to Draper Fisher Jurvetson (one of Silicon Valley's leading VC firms), the focus of which was to enable the design and assembly of nanoscale systems based on the parts currently available in *Nature*. I was *not* laughed out of the room. There are fairly clear paths, at least to me, from such biotechnology enabled nanotechnology to the "hard/dry" nanotechnology of the type envisioned by Drexler. Nanotechnology is coming whether Tom understands it or not.

Now, whether a structure like Tony Daniel's interplanetary network of hollow tubes is possible, even with nanotechnology, is doubtful. Arguments have been around for 35+ years that Dyson "spheres" cannot be built (from any material) due to the stresses to which they would be subjected. I strongly suspect that similar arguments would show that Daniel's tubes are unworkable. Such a structure could only be built in "free space" away from a large gravitational field. What can be built are Dyson "shells," as I've documented in a recent paper published in the OSETI III proceedings.

Tom should learn to differentiate between nanotechnology based on hard science (Drexler's Nanosystems, Freitas' Nanomedicine, etc.) and nanotechnology based on the imaginations of science fiction writers who don't bother to incorporate the necessary physics and math into their creations. While *The Spike* has a few minor mistakes with regard to the analogies it uses or its word phrasings, it is one of the best outlines of the future facing humanity currently available.

Robert Bradbury
President
Aeiveos Corporation

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Dear Dr. Schmidt,

Reading Ben Bova's *The Precipice*, I am struck by the author's obvious prejudices. I think he's right that we stand on a precipice of a sort, but not the kind he imagines.

Bova's assumptions about the environment, energy, space travel, etc. seem outdated. In fact, they seem to come straight out of various space books published in the 1970s. Not to call him backward, but he sure does like those old concepts a lot.

In general, Bova seems disposed toward monolithic thinking, the old Bigger Is Better syndrome. Solar power satellites, gigantic fusion reactors and a whole community dedicated to mining that elusive ghost Helium 3 may all be appealing to lovers of Big Projects, but the real future is trending in the opposite direction: from big to small, from centralized to decentralized and from codependence to independence.

I'll list just three differences here. First, fusion: it's obvious all those Tokamaks and laser imploders, what I like to call Big Money Fusion (BMF), will never work. Their purpose is not to generate power but to generate paper, in the form of money for university physics departments and the reports of the academics employed there. Bova has shown a loyalty to academia some might find admirable, but it's hardly realistic.

A better candidate for fusion energy is the fusor. It's small, it's cheap, it does produce fusion, and it may soon generate electricity directly without boiling water. The fusor shows promise to being the powerplant of choice for small homestead and outposts, whether on this planet or in space. Of course it takes away all the glory from your average physics department, but that's the price of progress.

Second, space travel and civilization. Space is big enough that any small group can basically do what they want once they're away from Earth; there's no way to stop them. It's outlaw heaven. So, the idea of the UN controlling things is hard to swallow. Even if they do get control of Mars and the Moon, people will just go to smaller places where they can't be seen, hiding in the nooks and crannies of the Solar System.

Even on the Moon—hell, even on Earth!—there's plenty of room to be free. Far from being a place of UN oppression, space will be a free for all of independent micronations leaving the bureaucracies of the mother planet behind.

Finally, nanotechnology. Molecular assemblers will make just about anything cheap to make, and just about anywhere too. With nanotech, there is little need for a city like Selene. Also with nanotech, in line with the decentralizing trend of today, there would be an explosion of people leaving the Earth and/or transforming it to their liking. Imagine kids copying hardware the way they copy software now. It would be just like that; punk technology, really.

The science fact article in your latest issue quotes the old saw that the Universe is not only stranger than we imagine, it's stranger than we can imagine. At this time in history, maybe the same is true for our own future.

Bob Sindeldecker
Columbus, Ohio

The author replies...

Obviously, I disagree. And I think *your* prejudices have led you to misread a good deal of *The Precipice*. For example, what makes you think the fusion powerplants in the novel are huge tokomaks? The Duncan Drive fusion system described in the novel is quite compact. As Casey Stengle used to say, "You can look it up!"

Ben Bova

Dear Stan,

Applause, applause, for Dean MacLaughlin's "He Who Carried the Moon."

Not for the biographical information,

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which is also interesting and informative but not all that exciting, but for the description at the end of how science is done in the "real world." For a long time it has been fashionable in the SF community to denigrate any scientist who supports the scientific status quo, and refuses to uncritically accept any pronouncement of something (anything!) as "new" and "better" and "throw out the old: baby, bathwater and all" before it is known if the new even works, much less is better than the old.

I had written a letter to you on this subject quite a while back, and while it never saw publication, I was gratified to see you write an editorial on the subject some time afterward that agreed with some of my points. However, Dean's explanation is far superior to my description and, I dare say, even to your editorial. There is a fairly well-known statement about pronouncements of "old and revered scientists" who don't immediately promote any new concept that comes along without supporting evidence. That statement is a cheap shot at the many dedicated scientists (revered or not) who work hard at trying to evaluate the new in the light of the old and reconcile them, and don't deserve the jibes they get from the SF community when they don't immediately jump on any bandwagon that comes along—even when they're mistaken. Save the jibes for the pseudoscientists out there. I hope that your readers will read Dean's comments carefully and take them to heart, and reject the denigrating attitude that has become fashionable.

Howard Mark

Dear *Analog*,

I expect that *Analog* will contain thought-provoking and intelligent fiction.

I expect that its editors will maintain the highest of standards when reviewing and accepting fiction for publication. I expect to feel that the time I spend reading *Analog* will be time well spent. Perhaps I expect too much.

"Naked Came the Earthling" was bad. And it was bad for twenty-five pages. I understand the pressing need to fill the double issue. But I have to wonder, what quality work did your editorial staff reject so that this piece could be accepted? Perhaps it was thought that this work was witty, even pithy. A sly commentary on our society's fixation on the superficial and our leadership's inability to act beyond that fixation and the ease in which that leadership weakness could be exploited. Perhaps your editorial staff was intoxicated. I'm not sure.

What I am sure of is that the editors of a magazine of your quality should have known better. While I considered directing my time and energies toward your competitors, I have decided that one bad decision can be forgiven. I hope I am not disappointed so gravely in the future.

Matthew Harmon
Washington

I'm sorry you didn't like the story, but you don't seem to have considered an alternative hypothesis: that it simply wasn't to your personal tastes, and other readers, equally intelligent and thoughtful, might have different ones that deserve no less consideration. I've heard from other readers who liked that story as much as you disliked it. As an editor, I've learned that it's quite impossible to satisfy everybody with anything, or anybody with everything. I can only hope that readers will recognize that and "read around" the occasional story that does nothing for them, but a lot for somebody else. (Maybe it would help if our language didn't treat "good" and "bad" as adjectives, making it sound as if they actually describe intrinsic and objective properties!)

Dear Dr. Schmidt,

I just finished reading "The Walls That Bind," and I was left wondering about a

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few things. Why did the aliens never abduct amputees? I can still do everything I did before I lost my leg, and I've been told by men (and lately a few women!) that I'm still damn sexy, even though I use crutches full-time. I think these aliens need to be sued under the Americans with Disabilities Act!

If amputees are always left behind, wouldn't there be some people who are so afraid of being abducted that they'd stick a leg across a railroad track or something?

Also, if the aliens' pattern was to abduct everyone but "oldsters, amputees, babies without mothers and a few rejected for no known reason," then why was Carlie's abduction group all female? Nobody seemed to wonder whether the aliens had either changed their pattern of abduction or if they separated men and women after abduction.

Judy Liimatainen

P.S. Sorry about leaving off my return address, but some men, and a few women, are so obsessed with finding an attractive one-legged woman that they'll make an unbelievable effort to follow up even the slightest clue to finding one.

The author replies...

Congratulations on your accomplishment in re: the crutches. As someone who did spend some time on crutches, thankfully temporary, I realize just how much blood, sweat, toil, and tears this victory cost you. But don't you see, you've answered your own question. Someone who has struggled to overcome a handicap is likely to be more determined, more creative, more careful, more a lot of good things than someone who hasn't. And this might be a reason that alien abductors would leave them behind.

And as for there only being human females behind the wall with Carlie and her friends, this doesn't mean that only females were abducted, or that the females who were abducted wouldn't worry and wonder about the males. But this was a short story, and therefore, not every plot avenue could be explored. Yet.

Jayge Carr

Dear Dr. Schmidt,

I have read all of the letters in the July/August Issue commenting on your "Child's Play II" in the February issue. I felt that I had to answer you and most of the letter writers you chose to print, because I am one of the few (that are still alive and able to type) of the generation that "have been out of school too long."

Yes, moderation is practically always a good idea. Micromanagement is obviously not 'moderation.' But "All work and no play" does not necessarily make Jack a dull boy. If it develops a work ethic for adulthood, and it will probably buy Jill a lot of diamonds. I know there is limited space for an editorial and (as is good practice) you try to stick to one facet of a subject, but the entire discussion about schoolwork and vacation did not mention *chores.*

I believe your editorial and most of the "crybaby" adults who have agreed with you (or even gone more extreme) have missed the point. "You can lead a horse to water, but you can not make him/her/it drink" is true and, also true, too much force frequently causes a result opposite to the intended result. *But something has to be tried.* R. Wimmer's letter touches on some of the points i.e. we are losing out in international competition. Already in the late 70s, my son reported that some of his friends shunned classes with too high a number of Asian students. Why? Because they did not like the stiff competition!

U. of Cal is for the top 10% of students that go to college, but at the parents' Orientation Meeting at the Santa Barbara campus, it was said "If you have sent your child here to learn subjects *which are pertinent to his future employment* you have chosen the wrong school," my jaw dropped and my son left after the

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first semester. I received my BS in Chemical Engineering from a university where we carried 18 units [3 hrs/wk per unit for the average student to get a C] That is 54 hrs/wk, but some classes had become extremely competitive. For example, a 1 unit Physical Chemistry Lab took about 7 hrs, not 3. In most classes, a distribution curve was considered when the grades were assigned. Most of the students in this private University were in at least the top 20% of their high school class. To ease some of the pressure, Purdue and other engineering schools have added a compulsory summer session to graduate in 4 years. Back then, 4 years was the norm, because you had to get to work and make a living.

I, also, am not typical (who is?) because I graduated from high school at age 16, first in my class. I loved to read. In the Midwest summer ("Only mad dogs and Englishmen go out in the midday sun"), I would retire to a couch in our basement (in those days, only theaters had air-conditioning), my dog would curl up next to me, and I would read Tom Swift (32 vols.), Tarzan (8 vols?), Albert Payson Terhune's and Jack London's dog stories, etc. I would read an entire Tom Swift book in an afternoon.

To further comment on R. Wimmer's letter, the 40-hour workweek has been forced by Unions (in many jurisdictions, bricklayers only work 35 hrs., meaning they work 40 hrs. or more but are paid time and a half for over 35 hrs.), but there are many thousands of small shopkeepers, contractors, CPA's and other self-employed, plus salesmen and business executives who are employed by companies, (who are neither underqualified nor work for a slave driver) who work much more than 40 hrs/wk.

Like E.G. Robles, I too was lucky! I liked my work as a Process Engineer designing, building, and operating chemical plants for a subsidiary of a large oil company. During WWII, we worked (officially) 48 hrs. and I volunteered to teach a class (Process Instrumentation) to night school at Long Beach City College. I never felt that I was working for a "boss." In my opinion, if the work I did was good for the company, it was, also, good for me. Maybe that is why I was a Department Manager when I was 27 years old.

I know this is too long to print, but even if it gives you some ideas for future editorials, it will have been worth my time. I think the comment on "too much competition in High School from Asians causing WASPS to shun those classes" and the Cal Santa Barbara statement on "*not pertinent* to your future employment" might be worthy of print!

Alwien Dierl
Long Beach, CA

All work and no play does usually make Jack a dull (and probably unhappy boy)! All play and no work makes him and irresponsible and incompetent (and, in the long run, probably unhappy) boy. What we need is a reasonable balance, but instead we spend most of our time oscillating between one unhealthy extreme and another. ■

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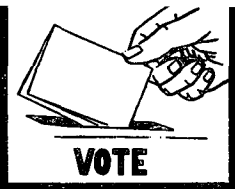

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Look over all your copies of Analog dated 2001, or refer to the index on the preceeding pages. Pick your three favorites in each of the following categories: novella, novelette, short story, science fact article, and cover. If you're not sure about a piece's category, you'll find it listed both in the Table of Contents for the issue in which it appeared, and in the Index. In the event of a disagreement between the Table of Contents and the Index, the Index should be considered correct. List your choices in order of preference (your favorite in each category is #1) on the ballot below, and either mail it in or send it by e-mail. You can also vote at our website, **www.analogsf.com**. The ballot is intended to make it easier for you to vote, but if you don't want to cut it out, feel free to copy it.

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2001 Index

Here is the Index to 2001, Analog's Volume 121. Entries are arranged alphabetically by author, with month and page. When the author's name and/or part of the entry's title is omitted, it is the same as that of the previous entry. Multiple entries by the same author are listed alphabetically according to the story/article title. Collaborations are listed under all authors with cross references. Unless otherwise noted, each entry is identified as an Alternate View (av), editorial (ed), fact article (fa), guest editorial (ge), novella (na), novelette (nt), poem (pm), Probability Zero (pz), serial (ser), special feature (sf), or short story (ss).

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IN TIMES TO COME

Our lead novella for February is Edward M. Lerner's "Presence of Mind," a relatively near-future cautionary tale—about, among other things, caution. As human beings seek ever better control of their machines, they strive for increasingly seamless interfaces. Such an interface makes it easy to transfer information you want between nervous systems and digital devices, but by the same token makes it easy to transfer unwanted—maybe even deadly—information. It makes for a decidedly scary situation, and two big problems: one to be solved with all possible urgency, and then the bigger one of what you do—or don't—in terms of changing your behavior afterward. We'll also have Part II of Robert J. Sawyer's *Hominids*, plus short fiction by Mia Molvray and (after too long an absence) Mark Rich. Richard A. Lovett, Ph.D. provides the science fact article, with some new findings on life under the very extreme conditions of Antarctica—and speculations on what they may imply about life in slightly more exotic places like Mars and Europa.

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UPCOMING EVENTS Anthony Lewis

18–20 January 2002
ARISIA '02 (Boston speculative media conference) at Boston Park Plaza Hotel and Towers, Boston, MA. Guest of Honor—Katherine Kurtz; Artist Guest of Honor—Tristan Alexander; Fan Guest of Honor—Eugene Heller. Info: Arisia, Inc., 1 Kendall Square, PMB 322, Building 600, Cambridge, MA 02139. URL: www.arisia.org

18–20 January 2002
CHATTACON 27 (Tennessee SF conference) at Clarion Hotel, Chattanooga, TN. Guest of Honor—Melanie Rawn; Artist Guest—Robert Daniels; Special Guest—Jack McDevitt; TM—Charles Grant. Registration: $30 until 31 December 2001, $40 thereafter. Info: Chattacon 27, Box 23908, Chattanooga, TN 36422-3908. email: info@chattacon.org; URL: www.chattacon.org

18–20 January 2002
CONFUSION 2002 (Ann Arbor area SF conference) at Van Dyke Travelodge, Warren, MI. Guest of Honor—George R.R. Martin; Artist Guest of Honor—Pete Abrams; Science Guest of Honor—Br. Guy Consolmagno; Fan Guest of Honor—Heather Alexander; TM—Sharon Myers Shaw. Registration: $30 until 1 November 2001; $35 at the door. Info: ConFusion, Box 8284, Ann Arbor, MI 48107. email: confusion@stilyagi.org; URL: www.stilyagi.org/cons/confusion.html

25–27 January 2002
VERICON (Harvard SF conference) at Sever Hall, Harvard Yard, Cambridge, MA. Info: HRSFA, c/o 4 University Hall, Harvard College, Cambridge, MA 02138. URL: www.vericon.org

29 August–2 September 2002
CONJOSE (60th World Science Fiction Convention) at Convention Center, et al., San Jose, CA. Guests of Honor—Vernor Vinge, David A. Cherry, Bjo & John Trimble, TM—Tad Williams. Registration: $140 until 10 July 2001, more thereafter. [These are the latest rates posted on the Internet as of the time this column went to press.] This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info: ConJose, Box 61363, Sunnyvale, CA 94088-1363. email: info@conjose.org, URL: www.conjose.org

Convention runners: If your convention has a telephone, FAX, email, or web page URL, please let us know so that we can publish this information.

Convention attendees: When calling conventions for information, do not call collect and do not call too late in the evening. It is best to include a S.A.S.E. when requesting information; include an IRC if the convention is in a different country. ■

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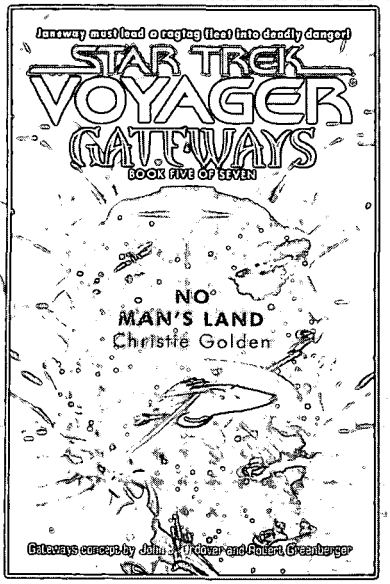
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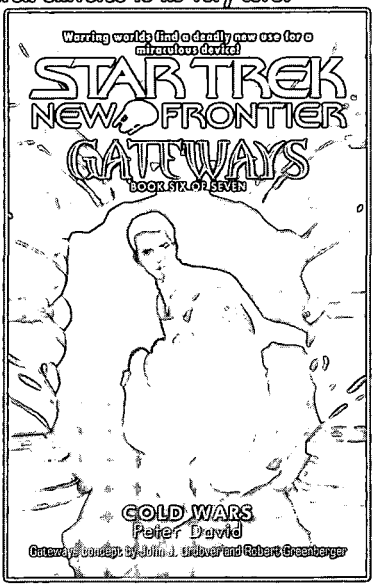
NO MAN'S LAND
Christie Golden
Gateways concept by John J. Ordover and Robert Greenberger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